Moderation of Sensation Seeking Effects on Adolescent Substance Use

by

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ABSTRACT

Adolescent substance use carries a considerable public health burden, and early initiation into use is especially problematic. Research has shown that sensation seeking traits increase risk for substance use experimentation, but less is known about individual and contextual factors that can potentially protect against this risk. This study utilized a longitudinal sub sample of youth (N=567) from a larger study of familial alcoholism to examine sensation seeking in early adolescence (ages 10-15) and its relations to later substance use experimentation. Hypotheses tested whether individual executive control, parenting consistency, neighborhood disadvantage, and neighborhood ethnic concentration moderated sensation seeking's effects on substance use experimentation using multilevel zero-inflated Poisson modeling. Across models, higher levels of sensation seeking were predictive of a higher likelihood of having initiated substance use, but sensation seeking was not significantly related to the number of different substance use classes tried. Only neighborhood disadvantage emerged as a significant moderator of the path from sensation seeking to substance use initiation. The strength of sensation seeking effects on substance use initiation increased as neighborhood disadvantage decreased below average levels, with the most advantaged neighborhoods exhibiting the strongest link between sensation seeking and substance use. There was also a trend towards the most disadvantaged neighborhoods exhibiting increased sensation seeking effects on substance use initiation. These results highlight the importance of focusing on relatively more advantaged areas as potentially risky environments for the externalizing pathway to substance use.

This dissertation is dedicated to the memory of my grandparents, Robert and Jane Jensen, who valued science and scholarship and taught me to love it too.

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Introduction

Adolescent substance use is a pressing public health concern, linked with increased risk of substance use disorder (SUD) and the leading causes of adolescent death (Centers for Disease Control and Prevention, 2010; DeWit, Adlaf, Offord, & Ogborne, 2000; Grant & Dawson, 1998). Substance use in adolescence is common, with 70.8% of high school students reporting lifetime use of alcohol, 44.7% having ever tried cigarettes, and 39.9% having tried marijuana (Centers for Disease Control and Prevention, 2012). Problematic use also occurs, with 21.9% of high school students reporting past month binge drinking. The high prevalence of adolescent substance use, combined with the potential consequences of such use, underscore the importance of prevention of early onset adolescent alcohol and other drug use. An understanding of the etiology of adolescent substance use is necessary for the development and improvement of preventive interventions.

One risk factor for substance use that has received considerable recent attention is disinhibition, or the inability to constrain one's behavior and impulses (Iacono, Malone, & McGue, 2008; Verdejo-García, Lawrence, & Clark, 2008). Disinhibition consistently relates prospectively to SUD and symptoms (Chassin, Flora, & King, 2004; Elkins, King, McGue, & Iacono, 2006; Robert F. Krueger, 1999; Piehler, Veronneau, & Dishion, 2012; Sher, Bartholow, & Wood, 2000). Disinhibition represents an endophenotype for the "externalizing pathway" to substance use, thereby transmitting an underlying genetic liability for adolescent substance use and other problem behaviors (Iacono et al., 2008; Zucker, Heitzeg, & Nigg, 2011). Evidence from studies of twins and children of

alcoholics strengthens this liability hypothesis, showing that disinhibition mediates the effects of genetic risk and familial substance use on adolescent substance use and externalizing behaviors (Hopfer, Crowley, & Hewitt, 2003; S. M. King et al., 2009; Robert F Krueger et al., 2002; Tarter, Kirisci, Habeych, Reynolds, & Vanyukov, 2004) and that covariation among externalizing behaviors is especially related to disinhibition (Cooper, Wood, Orcutt, & Albino, 2003).

However, disinhibition is a complex, multi-faceted construct, and increasingly evidence suggests that different facets of disinhibition may present differential levels of risk for substance use and therefore should be considered separately (Dick et al., 2010). For instance, characteristics including impulsivity, behavioral under-control, and sensation seeking are all constructs that have been considered under the same umbrella of disinhibition (Dick et al., 2010). Several lines of research converge on dual systems models that distinguish between a top-down, executive control system and a bottom-up reward sensitivity system as important unique components of disinhibition (Casey & Jones, 2010; Hare, Camerer, & Rangel, 2009; Steinberg, 2010; Urcelay & Dalley, 2012; Van Leijenhorst et al., 2010; Wiers et al., 2007; Zelazo & Carlson, 2012). One such dual-process model with demonstrated utility distinguishes between executive control, involving effortful cognitive inhibition and suppression of behaviors and impulses, and reactive disinhibition, characterized by bottom-up processing of reward motivations, including attraction to novel or exciting situations (Blaskey, Harris, & Nigg, 2008; Nigg, 2000, 2003). The reactive disinhibition reward circuitry of the brain involves recruitment of midbrain structures and dopaminergic pathways (e.g. mesolimbic system, ventral

striatum) and their projections to the ventromedial prefrontal cortex. Sensation seeking, characterized by motivations to engage in novel, fun, or exciting situations, is a common operationalization of reactive disinhibition. Executive control, in contrast, is theorized to be a top-down process, involving effortful control in suppression of certain behaviors and impulses (Blaskey et al., 2008; Nigg, 2000), and is similar to conceptualizations of "cool" cognitive processes (Zelazo & Carlson, 2012). The neuro-circuitry implicated in executive control is largely located in the prefrontal regions (Bechara & Van Der Linden, 2005; Mansouri, Tanaka, & Buckley, 2009; Zelazo & Müller, 2002).

Research on the differential risk for substance use associated with these different facets of disinhibition has been somewhat limited. However, existing research suggests that reactive disinhibition may be more consistently linked with substance use (Finn, Mazas, Justus, & Steinmetz, 2002; Sher et al., 2000; Urcelay & Dalley, 2012), while the support for the role of executive control is more mixed (Giancola & Parker, 2001; Handley et al., 2011; Nigg, 2006). A recent meta-analysis of impulsivity-related traits and adolescent alcohol use concluded that of all impulsivity facets considered, the reactive disinhibition constructs of sensation seeking and positive urgency were the most strongly related to adolescent alcohol consumption and binge drinking, both in cross sectional and prospective designs, though alcohol related problems and alcohol use disorders were more strongly predicted by the trait of urgency and not sensation seeking (Stautz & Cooper, 2013). This is consistent with some research suggesting that sensation seeking tendencies are perhaps most associated with early-stage alcohol and drug use and experimentation, while the progression to abuse and dependence may be more strongly

influenced by other factors (Smith et al., 2007; C. A. Winstanley, Olausson, Taylor, & Jentsch, 2010).

Emerging evidence also suggests that sensation seeking may be more useful in understanding transmission of familial risk for adolescent substance use. A recent study in the current sample showed that sensation seeking mediated the effect of familial drug use disorder on all externalizing spectrum problems, including having initiated any substance use, while executive control did not mediate familial risk (Handley et al., 2011). These results are consistent with research that shows reward processing may be a stronger predictor of self-reported likelihood of engaging in risky behavior than is trait impulsivity (Galvan, Hare, Voss, Glover, & Casey, 2007). Together, these results highlight the importance of sensation seeking in understanding pathways to youth substance use.

Internal Buffer of Sensation Seeking: Executive Control

Theory would suggest, and the limited evidence confirms, that *interactions* between executive control and sensation seeking are important in understanding adolescent substance use, with sufficient executive resources buffering against the ill effects of sensation seeking (Finn, 2002; Hoffmann, 2002). It has been argued that dual process interactions between approach impulses and inhibitory control are the best ways to understand substance use and addiction (Smith et al., 2007). For example, specific alcohol and drug approach tendencies exert stronger effects on alcohol and drug use in the presence of weak executive control (Grenard et al., 2008; Peeters et al., 2012; Thush et al., 2008; Wiers et al., 2007). Studies of temperament also reveal stronger effects of

sensation seeking and other reactive disinhibition constructs on alcohol use when inhibitory controls are weaker (Dvorak, Simons, & Wray, 2011; Willem, Bijttebier, & Claes, 2010). For instance, Willem et al. (2010) demonstrated cross-sectionally that the effect of fun seeking on quantity and frequency of alcohol use was moderated by effortful control, such that fun seeking's relation with alcohol use was only significant when effortful control was low. In a cross sectional analysis of the same dataset to be used here, Handley et al. (2011) examined interactions between task indicators of executive control and sensation seeking, showing that response inhibition was in fact capable of reducing the concurrent relations between sensation seeking and externalizing behaviors, including having initiated any substance use. Taken together, this emerging evidence provides support for dual-process interactions between executive and reactive systems. However, there are a paucity of studies examining dual process interactions between sensation seeking and executive control predicting substance use in longitudinal samples. This is particularly problematic given evidence that alcohol and other drug use in adolescence can impact brain functioning, including the executive processes of working memory and inhibition (Squeglia, Jacobus, & Tapert, 2009). Cross sectional designs allow for causal misinterpretation of correlations between executive control and substance use. It may be that prior alcohol and drug use have resulted in lower levels of executive functioning, but that could be mistakenly viewed as temperamental executive control deficits *causing* one to use alcohol or drugs. Longitudinal studies are necessary in order to determine the directionality of these effects. The present study will seek to fill this gap in the literature by examining a dual process interaction between sensation seeking and executive control

in early adolescence and its ability to prospectively predict later adolescent substance use involvement (Research Question 1).

There are as many ways of operationalizing executive control as there are conceptualizations of facets of disinhibition. Measurement of executive control has included self or other report measurement of trait or temperament constructs including impulsivity (Eysenck & Eysenck, 1978), premeditation (Smith et al., 2007; Whiteside & Lynam, 2001), conscientiousness (McCrae & Costa, 1987), constraint (Patrick, Curtin, & Tellegen, 2002), behavioral inhibition (Carver & White, 1994), and effortful control (Conger et al., 1991). Often these operationalizations include a focus on acting without thinking and acting on impulse, though it is important to note that even scales with face-valid naming may include items that tap other dimensions of disinhibition, such as scales that tap both sensation seeking and executive control. The benefit of questionnaire measurement is that it tends to ask about *persistent* patterns of behavior over time. On the other hand, behavioral task paradigms have been designed and tested that tap the actions thought to underlie successful executive control of pre-potent responding or response inhibition (K.M. King, Patock-Peckham, Dager, Thimm, & Gates, 2014). Such tasks use response time and patterns of responding to test working memory, attention, and ability to inhibit responding in a certain manner. One advantage of behavioral task paradigms is that they are not subject to the same types of response biases seen in self-report questionnaire measures. Some research has shown that relations between and patterns of findings for task and traditional survey measures of executive control overlap both in children and adults (Chang & Burns, 2005; González, Fuentes, Carranza, & Estévez,

2001; Lane, Cherek, Rhoades, Pietras, & Tcheremissine, 2003). However, there is also another body of research that suggests that there are considerable differences and lack of correlation between the two types of measurement as well (Sharma, Markon, & Clark, 2014). It is notable that task measurement can capture situational effects (K.M. King et al., 2014). State variations in executive control can be useful in an experimental setting, but this can also yield results that are more impacted by testing administration and perhaps less characteristic of general responding. Moreover, behavioral tasks are not "process pure"; for example tasks tapping working memory may also require attention and motivation resources for successful performance of task demands. Of the three existing studies testing dual process interactions between executive control and reactive disinhibition on adolescent alcohol and substance use, one used behavioral task paradigms to measure facets of executive control (Handley et al., 2011) and two utilized inventory reports on child/adolescent executive control-related behaviors (Dvorak et al., 2011; Willem et al., 2010). Given that the field has not yet converged on a best-practice for measurement of executive control, the current study will use both task executive control and questionnaire executive control measures in hopes of achieving convergent validity in the role of executive control as a moderator of sensation seeking effects.

External Buffer of Sensation Seeking: Parenting Consistency

In addition to the potential buffering effect of executive control, environmental factors may also modify sensation seeking risk for substance use. Effective parenting has long been acknowledged as one of the most important developmental contexts, and has an established relation with adolescent substance use (Barnes & Farrell, 1992; Barnes,

Reifman, Farrell, & Dintcheff, 2000; Baumrind, 1991; Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2000). In particular, consistent discipline (i.e. establishing rules and reliably enforcing them) demonstrates effects on adolescent substance use and other problem behaviors (Dishion, Capaldi, & Yoerger, 1999; Dodge et al., 2009; K. M. King & Chassin, 2004).

Some evidence suggests that effective parental controls can improve the developmental outcomes of disinhibited children (Bates, Schermerhorn, & Petersen, 2012). For instance, parental control and consistent discipline interact with disinhibition to predict substance use and externalizing problems, with the most disinhibited children benefitting most (Chen & Jacobson, 2013; Lengua, Wolchik, Sandler, & West, 2000; Stice & Gonzales, 1998). These findings are qualified, however by results suggesting that, although disinhibition and family processes do interact, the protective benefits of families are limited such that at the highest levels of individual risk the benefits of family protections are less influential (Cleveland, Collins, Lanza, Greenberg, & Feinberg, 2010). Cleveland et al. (2010) used composite measures of individual risk (an index of several factors including sensation seeking, rebelliousness, and belief in immoral order) and family processes (an index including attachment and supervision), however, which makes it difficult to draw conclusions about parental consistency of discipline and sensation seeking specifically. Another study demonstrated that authoritative parenting in the 6th grade was capable of diminishing the effects of sensation seeking on adolescent substance use attitudes and intentions in the 8th grade, but did not influence actual behaviors (Stephenson & Helme, 2006).

The present study will address some of these limitations by targeting the interaction between a known specific individual risk (sensation seeking) and a known modifiable parenting factor (consistency of discipline) on later adolescent substance use experimentation. It is possible that effective parenting control will be capable of reducing the power of sensation seeking to impact substance use, perhaps by limiting adolescent exposure to substance use contexts and negative peer influence (e.g. enforcing a curfew). The present study will examine the nature of the interaction between parenting and sensation seeking, probing for protective but reactive moderation such that at the highest levels of sensation seeking parenting consistency loses its buffering effect (Research Question 2). Results will have potential to inform preventive efforts; the dispositional vulnerability of sensation seeking may not be easily amenable to intervention, but established interventions have a proven record of successfully modifying parenting practices (Dishion, Nelson, & Kavanagh, 2003; Spoth, Redmond, & Shin, 2001). Effective parenting could be emphasized as an intervention target among adolescents high in sensation seeking.

External Buffer of Sensation Seeking: Neighborhood Organization

The aforementioned internal and familial controls coexist within broader community environments which can also potentially work to constrain adolescent behavior. There is strong evidence that substance use clusters geographically, with some neighborhoods exhibiting higher rates of use than others (Karriker-Jaffe, 2011). Considerable evidence has accumulated over the past several decades that certain types of structural neighborhood environments, characterized by disadvantage and

disorganization, present a substantial risk for a host of negative child and adolescent behavioral outcomes including substance use (Leventhal & Brooks-Gunn, 2000), though structural neighborhood effects are not always consistent (Karriker-Jaffe, 2011). The mechanisms through which structural neighborhood factors exert their effects have been the topic of much speculation, with theories including mechanisms like paucity of institutional resources, collective socialization, social contagion, competition for resources, and relative deprivation (Leventhal & Brooks-Gunn, 2000). Social disorganization theory offers a cohesive explanation for neighborhood risks, positing that the neighborhood factors of disadvantage, residential instability, and ethnic heterogeneity all hamper residents' ability to build cohesive networks and social capital within their communities, and thus undermine their ability to share values and enact social control over behavior in the community (Sampson, Raudenbush, & Earls, 1997). Although the present study was not able to address the specific mechanisms of structural neighborhood effects, it offers valuable insights about whether two facets of structural neighborhood organization are capable of buffering sensation seeking's risk for substance use.

Much research shows that adolescents living in disorganized environments are more likely to engage in problem behaviors, including substance use. For instance, adolescent perceptions of neighborhood disorganization and disorder have been linked to higher rates of substance use and dependence (Jang & Johnson, 2001; E. L. Winstanley et al., 2008). Higher levels of census-defined neighborhood disadvantage has repeatedly demonstrated links to increased adolescent substance use in community samples (Abdelrahman, Rodriguez, Ryan, French, & Weinbaum, 1998; Buu et al., 2009; Crum,

Lillie-Blanton, & Anthony, 1996; Hoffmann, 2002; Smart, Adlaf, & Walsh, 1994). These results are supported by experimental work wherein adolescents who were randomly assigned to remain in their low income neighborhoods exhibited more substance use and arrests compared to those youth who were moved to more affluent neighborhoods (Briggs, 1997; Leventhal & Dupéré, 2011). There is substantial contrasting work, however, suggesting that relations between neighborhood disadvantage and substance use may not be so clear cut (Bryden, Roberts, Petticrew, & McKee, 2013; Jackson, Denny, & Ameratunga, 2014; Karriker-Jaffe, 2011). Some studies fail to find a significant disorganization-substance use link (Allison et al., 1999; Brenner, Bauermeister, & Zimmerman, 2011; Buu et al., 2009; Esbensen & Huizinga, 1990; A. A. Fagan, Wright, & Pinchevsky, 2015; Hoffmann, 2002), while others indicate that adolescents in the most *advantaged* neighborhoods may be at increased risk for substance use (Ennett, Flewelling, Lindrooth, & Norton, 1997; Luthar & D'Avanzo, 1999; Snedker, Herting, & Walton, 2009).

There is corresponding ambiguity surrounding the effects of neighborhood ethnic concentration. Though traditional social disorganization theory suggests that ethnic *homogeneity* facilitates social control, scholars historically conceptualized ethnic concentration as a linear risk factor, such that increasing numbers of immigrant and ethnic minority residents undermine the white majority's ability to maintain common values and thus increase disorganization. Consistent with this approach, there is evidence that increasing proportions of immigrant and Latino residents are predictive of crime (Sampson & Groves, 1989; Sampson et al., 1997) and substance use (Frank, Cerdá, &

Rendón, 2007). Increasingly, however, researchers are realizing that modern Latino immigration patterns have resulted in a rise in prevalence of highly concentrated Latino neighborhoods which can also prove protective against problem behaviors. Recent research has shown that higher numbers of immigrant and Latino residents are actually related to lower crime rates, reduced adolescent violence, and less adolescent risk taking (A. A. Fagan et al., 2015; Martinez Jr, 2002; Molina, Alegria, & Chen, 2012; Sampson, Morenoff, & Raudenbush, 2005; Tonry, 1997). The mechanisms for these *ethnic enclave* effects could include the proliferation of shared cultural practices and principles like family values and promotion of parental authority (Eschbach, Ostir, Patel, Markides, & Goodwin, 2004; Portes & Zhou, 1993) but are also consistent with social disorganization theory's emphasis on the protective benefits of living in an ethnically *homogenous* (here homogenous Latino) community.

The pattern of findings in the neighborhood organization literature suggest that perhaps there are complex, non-linear processes at work, with both highly disadvantaged communities imparting risk for SU, as well as more advantaged/affluent communities. Similarly, evidence suggests that perhaps at both very low concentrations of Latino residents (high white concentrations) and very high concentrations of Latino residents, which both represent *homogenous* neighborhoods that are theoretically expected to increase organization and social control over behavior, substance use risks may be reduced. This study will account for this pattern of effects by modeling non-linear relations in Research Question 3.

There is building evidence that social neighborhood organization *interacts* with disinhibition in predicting problem behaviors, though the nature of that interaction has varied across studies and operationalization of disinhibition, and effects on substance use have not been investigated. Several studies have yielded results consistent with the classic sociological theory that certain "weak situations", characterized by lack of explicit behavioral norms, will allow for expression of personal dispositions, while "strong" situations will pull for certain behaviors regardless of individual differences (Mischel, 1977). Often highly organized neighborhoods are conceptualized as strong situations where established community bonds and social control proscribe disinhibited behaviors. For instance, Lynam et al. (2000) found that a multi-method impulsivity composite was more strongly related to offending in lower SES neighborhoods, while in more affluent neighborhoods impulsivity had little effect. Perceptions of neighborhood social processes akin to social disorganization seem to play a similar role. For instance, in a sample of young adults, lack of premeditation and thrill/adventure seeking more strongly predicted offending among those youth who perceived their neighborhoods as low in informal social control (Jones & Lynam, 2009). Meier, Slutske, Arndt, and Cadoret (2008) similarly found a stronger relation between a short impulsivity measure and delinquency for those respondents who characterized their neighborhoods as low in collective efficacy (a combination of social control and neighborhood cohesion). Some evidence suggests that neighborhood organization is not always protective, however; one study concluded, consistent with a personality approach to crime, that an impulsivity measure's effects on delinquency were invariant across levels of neighborhood disadvantage (Vazsonyi,

Cleveland, & Wiebe, 2006). Another study found stronger effects of an impulsivity measure on delinquency in communities that were *higher* in collective efficacy and advantage (Zimmerman, 2010). These results can be interpreted as evidence that perhaps more disorganized, disadvantaged communities are "strong" situations with criminogenic cultures that pull for deviancy regardless of temperamental disposition. This study sought to extend and clarify this existing literature on problem behaviors and delinquency, and will be the first study to examine neighborhood moderation of sensation seeking's effects on substance use specifically. These analyses will also allow for the possibility that non-linear relations will emerge, empirically examining just how high and low levels of disadvantage and Latino ethnic concentration contribute to substance use experimentation, and how the effects of sensation seeking will vary across these facets of neighborhood organization. Modeling quadratic interactions could help clarify some of the seemingly contradictory results in the present literature. Results have the potential to inform the development and delivery of interventions at the community level. Although interventions targeting structural factors are not unprecedented (Briggs, 1997; Leventhal & Dupéré, 2011), more feasible, smaller scale interventions could also be implemented targeting disorganization through social factors by building connections among neighbors and increasing residents' collective efficacy, empowering them to exert social control in their communities.

Additive Protective Effects

The evidence presented here that factors at the individual, family, and neighborhood levels are all *independently* capable of buffering the effects of sensation

seeking raises the question of whether each exerts an independent moderating influence, or if the moderating effect of one is diminished once the others are taken into account. No known study has empirically examined the moderating capabilities of all three levels simultaneously on any outcome. The few studies that have examined *neighborhood* and *family* moderators in tandem failed to reach a consensus about added benefits, using disparate conceptualizations of neighborhood protections, family protections, and disinhibition in predicting delinquency (Barker, Trentacosta, & Salekin, 2011; Chen & Jacobson, 2013; Trentacosta, Hyde, Shaw, & Cheong, 2009). The present study sought in Research Question 4 to address the lack of consistency in this literature by examining the additive interactions of sensation seeking with executive control, parenting consistency, and neighborhood organization in order to test the hypothesis that each additional buffer would provide additive protective moderation against the deleterious effects of sensation seeking on substance use experimentation. The analyses sought to improve upon the existing literature by considering additive neighborhood moderation by neighborhood disadvantage and ethnic concentration, and whether perhaps curvilinear neighborhood effects were at play. This study was designed in hopes of advancing our understanding of how dispositional liabilities for substance use play out in complex environments, and informing interventions that can act on one or several of these dimensions. Interventions which take a holistic approach and target multiple levels of risk are effective at reducing adolescent drug and alcohol use (Hawkins et al., 2009), and could be improved by a better understanding of how the dispositional liabilities a child brings to the table might influence the behavior change process.

The Present Study: Research Questions and Hypotheses

The present study addressed the question of whether individual and parent level controls, along with organized neighborhood environments, are protective against sensation seeking's risk for adolescent substance use. At present, the field requires a clearer understanding of conditions under which the risk for substance use conferred by sensation seeking is or is not actualized in order to proceed with the development of interventions to protect against said risk. This study is poised to make a significant contribution to the body of literature on the risks of sensation seeking for adolescent substance use, examining whether sensation seeking's risks can in fact be attenuated, and by what factors. To this end, the study had four specific research questions:

Research Question 1 (Dual Process Moderation): Does individual level executive control serve as a buffer against sensation seeking's effects on adolescent substance use experimentation?

The following hypotheses were tested:

H1. Sensation seeking would prospectively predict increased rates of substance use.

H2. Executive control (measured in task and survey form) would prospectively predict decreased rates of substance use.

H3. Executive control would buffer against the effects of sensation seeking and result in a weaker link between sensation seeking and substance use experimentation when executive control is stronger. This study tested whether the hypothesized protective moderation of executive control replicated across task measures and inventory measures of executive control.

Research Question 2 (Parental Protection): Does parenting consistency serve as a buffer against sensation seeking's effects on adolescent substance use experimentation?

The following specific hypotheses were tested:

H1. Parenting consistency would be associated with less substance use experimentation.

H2. Parenting consistency would serve as a familial buffer against sensation seeking's effects on adolescent substance use experimentation such that the relation between sensation seeking and substance use experimentation would be weaker when parenting consistency is high.

H3. Additionally, consistent with prior evidence, it was hypothesized that a protective but reactive interaction between sensation seeking and parenting consistency would emerge such that at the very highest levels of sensation seeking the protective effects of parenting consistency would be diminished.

Research Question 3 (Neighborhood Moderation): Does neighborhood level organization (conceptualized as disadvantage and ethnic concentration) buffer against sensation seeking's effects on adolescent substance use experimentation?

The following hypotheses were tested:

Neighborhood Disadvantage

H1. Consistent with neighborhood disorganization theory, higher neighborhood disadvantage was hypothesized to prospectively predict increased rates of substance use experimentation (a linear relationship).

H2. In order to account for the somewhat inconsistent literature which suggests that both highly disadvantaged and highly affluent neighborhoods can impart risk, a quadratic relationship between neighborhood disadvantage and substance use was modeled, testing the hypothesis that both high and low disadvantage might impart risk for substance use.

H3. Consistent with the bulk of the literature on protective effects of less disadvantaged, more organized neighborhoods that prescribe prosocial behavior, it was hypothesized that neighborhood disadvantage would moderate sensation seeking's effects on substance use such that the risks associated with sensation seeking would be attenuated in those neighborhoods characterized by the least disadvantage, and exacerbated in those neighborhoods with highest levels of disadvantage (a linear interaction).

H4. Lastly, in order to account for some of the mixed findings on the nature of interactions between disinhibition and neighborhood disadvantage in predicting delinquency (Lynam et al., 2000; Vazsonyi et al., 2006; Zimmerman, 2010), a quadratic interaction between sensation seeking and neighborhood disadvantage was hypothesized, such that the effects of sensation seeking on substance use experimentation would be heightened in both low disadvantage (higher advantage) and high disadvantage neighborhoods.

Neighborhood Ethnic Concentration

H5. Consistent with the basic tenet of neighborhood organization theory that neighborhood ethnic homogeneity should be associated with less substance use,

and ethnic heterogeneity should be associated with more substance use, a quadratic relationship between neighborhood ethnic concentration and substance use was modeled, testing the hypothesis that both high proportions of non-Hispanic Caucasian residents (low proportion Latino) and high proportions of Latino residents (low proportion non-Hispanic Caucasian) would demonstrate lower rates of substance use than those more heterogeneous neighborhoods in between these two extremes. This hypothesis was also consistent with the emerging literature on the protective benefits of concentrated Latino ethnic enclaves, which may exert protective benefits through non-disorganization mechanisms.

H6. Consistent with the literature which conceptualizes ethnically homogenous neighborhoods as better organized and protective against antisocial behavior, it was hypothesized that neighborhood ethnic concentration would moderate sensation seeking's effects on substance use such that the risks associated with sensation seeking would be attenuated in both those neighborhoods characterized by high proportions of non-Hispanic Caucasian residents (low proportion Latino) and high proportions of Latino residents (low proportion Caucasian), while the most heterogeneous neighborhoods in between these two extremes would exhibit the highest rates of substance use.

Research Question 4 (Additive Protection and Risk): Do individual executive control, parenting consistency, and neighborhood organization provide additive protections against sensation seeking's risk for substance use experimentation?

The following hypothesis was tested:

H1. Buffers at the individual, family, and neighborhood levels would uniquely moderate sensation seeking's risks for alcohol and drug involvement, above and beyond the main and moderating effects of the other hypothesized buffers tested in questions 1-3.

Research question 4 was designed to build upon the models tested in questions 1-3, and explore whether those facets of executive control, parenting consistency, and neighborhood organization that emerged as significant predictors and moderators in questions 1-3 contributed unique variance in predicting alcohol and drug involvement and the moderation of sensation seeking's effects.

Method

Participants

This study utilized data from an ongoing longitudinal, multigenerational study of familial alcoholism risk (PI: Dr. Laurie Chassin). At the first wave of data collection in 1988, 454 adolescents (G2s) and their parents (G1s) participated. 54% of original G2 adolescents were children of at least one alcoholic parent (COAs) recruited using DUI records, HMO questionnaires, and community telephone surveys, and 46% were demographically-matched controls recruited from the same neighborhoods as COA families. All self-reported their ethnicity as either non-Hispanic white or Hispanic. Further details on the original sample and recruitment can be found in Chassin, Barrera, Bech, and Kossak-Fuller (1992). There were 3 initial waves of data collection at 1 year intervals, followed by 3 follow-ups five years apart. Retention of the original sample has

been excellent, with 90% of original G2s retained at Wave 6. Beginning at Wave 4, biological siblings of G2s that fell within the same target age range were also interviewed and added to the G2 sample.

At Wave 6, the biological children of G2s (G3s) were also interviewed and completed task measures of executive control. Wave 6 data was collected between the years of 2006 and 2011. Two additional Wave 6 follow-up interviews were conducted at about 18 months and three years after Wave 6. Data for the present analyses were drawn from the G3 cohort, with Time 1 (T1) data drawn from the Wave 6 interview for those G3's aged 10-15 years at Wave 6 (n=567; mean age=12.35). Given that G3s were recruited at different ages, there is considerable age heterogeneity in the G3 sample. This 10-15 year old age band ensures that that G3s are old enough to validly complete the behavioral measures of executive control but young enough to minimize the possibility of alcohol or drug use effects on executive functioning. One of the two follow-up assessments of substance use was used to assess Time 2 (T2) substance use experimentation (n=534; mean age= 15.9). G3s who were over 21 years of age at T2 and thus able to drink legally were excluded. G3s without a follow-up interview within the target age range were still included in the analyses using Full Information Maximum Likelihood (FIML) estimation to account for the missingness at T2. In the instances when both G3 follow-up interviews fell into the target <21 age range, the assessment at the older age was utilized to maximize variability on substance use outcomes.

Not all G3s have complete data on all variables. 220 youth are missing at least one T1 task measures of executive control or intelligence. These task measures are prone

to more missing data because those who were interviewed over the phone because they had moved out of the area or could not attend a home visit did not complete task measures. A total of nine youth have no primary caregiver participating in the study, and thus are missing parent report of their survey executive control as well as parents' report on their own parenting consistency. In order to avoid biasing the sample by not including those participants missing T1 task data or without a parent report, FIML was utilized and models estimated using the full T1 sample of youth.

Procedure

At wave 6 (T1) and the first follow-up, interviews were conducted at the family's residence or Arizona State University; the last follow-up interviews were conducted telephonically. In instances where an in-person interview was not possible a telephone interview was conducted instead. Written informed consent was obtained from the parents of minors, and adolescents gave assent at every interview. During telephone interviews verbal consent/assent was audio recorded. At every interview informed consent forms described the nature of the information to be asked in the interview, emphasized that participation was voluntary, and described confidentiality and its limits (i.e. risk of harm to self or others). Participants were made fully aware that they would be asked about substance use.

Measures

Across all T1 exogenous variables, efforts were made to reduce the possibility of shared reporter variance; the goal was to reduce the possibility that having the same reporter of independent variable and outcome would advantage those predictors over

others with a different reporter of the independent variable. Given that adolescent self-report of substance use was used at T2, T1 predictors all utilized parent report, behavioral task measures, or variables derived from census data. When multiple parents were available to report on child characteristics or behavior, mother and father report were evaluated for consistency. When correlations between parents were high combined mother and father reports were utilized. When correlations between parents were low, primary caregiver report was utilized. The primary caregiver was determined by examining parent and child responses on custody and living situation. In instances where both the biological mother and father had custody and contact, the mother was designated as the primary caregiver. For most youth (n=538); the primary caregiver was a mother or other female caregiver; 20 youths' primary caregivers were male, and nine youth did not have data from a primary caregiver (e.g. lived with un-interviewed grandparents or in some other custody arrangement). Descriptive statistics for all study variables are included in Tables 4 and 5.

Sensation Seeking. Zuckerman's (1979) six item Sensation Seeking Scale was employed to measure motivations for exciting and novel situations. Correlations between reporters were examined, revealing that mother, father, and adolescent report were all correlated significantly, but not strongly enough to justify averaging across reporters (see Table 1). Thus the primary caregiver's report on adolescent sensation seeking was used. Internal consistency among the six primary caregiving parent report items tapping sensation seeking sensation seeking was good (alpha=.82). Items referring to substance use were deleted from this scale. This revised Sensation Seeking Scale has predicted

concurrent adolescent initiation into any alcohol or drug use in a previous study in this same sample (Handley et al., 2011). Response options ranged from (1) "Strongly agree" to (5) "Strongly disagree". The mean sensation seeking score in the full T1 sample was 3.02.

Table 1
Correlations between Reporters: T1 Sensation Seeking

	Adolescent Report	Mother Report	Father Report
Adolescent Report	1		
Mother Report	.226***	1	
Father Report	.197***	.326***	1

Note. ***=$p \leq .001$

Executive Control. Two different conceptualizations of executive control were included in the present study. While considerable evidence has converged on the concept of top-down executive control as an important construct, the best way to measure that construct is still debated. Thus, here executive control was operationalized with separate measures of task and survey executive control.

Table 2
Correlations between Reporters: T1 Survey Executive Control

	Adolescent Report	Mother Report	Father Report
Adolescent Report	1		
Mother Report	.502**	1	
Father Report	.413**	.649**	1

Note. ***=$p \leq .001$

Survey Executive Control. Here survey executive control was measured using the Effortful Control composite of three subscales from the Early Adolescent Temperament Questionnaire Short Form (Capaldi & Rothbart, 1992), including activation control (example item: "I finish my homework before the due date"), attention

(example item: “When trying to study, I have difficulty tuning out background noise and concentrating” reverse scored), and inhibitory control (example item: “When someone tells me to stop doing something, it is easy for me to stop”). Effortful control is conceptualized as the ability to inhibit a dominant response and replace it with a subdominant response (Conger et al., 1991; Eisenberg, Smith, Sadovsky, & Spinrad, 2004). The literature has shown that these three temperamental scales consistently load onto the same factor and have good internal consistency and test-retest reliability (Thayer, Valiente, Hageman, Delgado, & Updegraff, 2002). Effortful control has been shown to predict conduct problems and mental health in adolescents, with mean levels similar to those seen in the present study (mean=3.29; Muris & Meesters, 2009). Here combined mother and father report of the adolescent’s survey executive control were used. Mother and father reported were adequately correlated to justify averaging across reporters (r=.649; Table 2). Response options for all items ranged from (1) “Almost always untrue” to (5) “Almost always true”. Internal consistency for combined parent report was good (alpha= .94).

Task Executive Control. Here task executive control is measured as a latent variable with three task indicators tapping dimensions of executive functioning: response inhibition, working memory, and spatial short-term memory/attention. This latent construct has been used in past research and correlated as hypothesized with risk factors like family disorganization and parental substance use (Wang, Chassin, Lee, Haller, & King, under review) and is consistent with previous research which shows that working memory and response inhibition consistently load on a single factor (Miyake &

Friedman, 2012). A three indicator single level confirmatory factor analysis was estimated with all indicators group mean centered (see Table 3); the zero degrees of freedom model precluded the examination of fit indices, but standardized loadings were strong, positive, in the hypothesized directions, and consistent with those seen in this same sample in Wang et al. (under review).

Table 3
Standardized Factor Loadings: Task Executive Control

Variable Indicator	Standardized β
Response inhibition	.728***
Working memory	.539***
Spatial short term memory and attention	.694***

Note. ***=$p \leq .001$

Response inhibition. The Immediate Memory Task (IMT) (Dougherty, Marsh, & Mathias, 2002) taps response inhibition by presenting 5 digit numbers and asking participants to press a button to indicate if the number displayed exactly matches the number in the previous trial. 600 trials were administered. In 200 trials the current and prior number matched, in 200 trials the numbers differed by one digit, and in 200 trials the number differed on all five digits from the previous trial. Trial response time and accuracy are recorded for each trial. Analyses used the number of single-digit commission errors (an indicator of impulsive responding) divided by the rate of correct hits to correct for response style; scores were reverse coded so that higher scores indicate greater response inhibition (mean = .598, SD = 0.21; Schmidt, Fallon, & Coccaro, 2004). The mean single digit commission errors score here (mean=58.55, SD= 25.50) is higher than the mean reported in the literature for this same task, which has been reported as

ranging from 22.17-34.04 in controls and 35.14-41.8 in clinical samples (Brendgen, 2012). The Immediate Memory Task employed here differs slightly from the original design in that Dougherty et al.'s (2002) original task which may account for this sample's elevated mean scores.

Working memory. The Letter Number Sequencing (LNS) subtest from the Wechsler Intelligence Scale for Children, Fourth Edition (Wechsler, 2003) was administered. Participants first listened to a combination of numbers and letters read aloud and then recalled the numbers first in ascending order and then the letters in alphabetical order. The scale score is used here as a test of working memory. The mean score in the T1 task sample was 10.19, which is very similar to the mean of 10 in normative populations.

Spatial short term memory and attention: The Matrix Span Task (Kane et al., 2004) was used to tap spatial attention and memory. 4 x 4 matrices were presented on screens with one of the 16 squares filled in in each matrix, and the respondent was cued to recall and mark the cells on a response sheet in the order presented. The outcome from this task is a sum of the proportion of correct responses, awarding partial credit for elements within a trial that are answered correctly, and is thought to be the most sensitive scoring option (Conway et al., 2005). The mean score in the T1 task sample (mean=.56) was similar to that seen in the literature (Kane et al., 2004).

Parenting Consistency: The primary caregiver's self-report was used to measure parenting consistency. Parenting consistency is a combination of the consistency of rule enforcement and discipline subscales (10 items) of the Children's Report of Parental

Behavior Inventory (Schaefer, 1965). Sample items include “I soon forgot the rules I had made “, and “I usually didn’t find out about my child’s misbehavior”. Response options ranged from (1) “Strongly disagree” to (5) “Strongly agree”. Internal consistency among the 10 items was good (alpha=.88). This same measure of parenting consistency prospectively predicted drug use disorder in the generation 2 sample, with mean levels of parenting consistency similar to the mean parenting consistency score (mean=4.04) seen here in the G3 sample (K. M. King & Chassin, 2004).

Structural Neighborhood Organization: G3s’ home addresses at T1 were geocoded and matched to a census-defined block group, which typically contain 600-3,000 residents. Census block groups were then matched to the 2000 Census, yielding a number of census-bock level measures of structural neighborhood factors which were used to create two measures of social neighborhood organization:

Disadvantage: Neighborhood disadvantage is measured as a z-score composite of percentage of families below the poverty line, percentage of families on public assistance, percentage of residents who did not graduate high school, percentage of female headed households, and percentage of unemployed residents. This is consistent with factor analyses suggesting that these neighborhood structural dimensions load on the same factor (Sampson et al., 1997). At T1 the neighborhood levels of percentage of families below the poverty line ranged from 0-46.59% (mean=8.94%), the percentage of families on public assistance ranged from 0-22.86% (mean=2.31%), the percentage of residents who did not graduate high school ranged from 0-65.58% (mean=16.57%), 0-69.52% of the families in the neighborhood were female headed (mean= 20.93), and neighborhood

unemployment rates ranged from 0-14.83% (mean=4.09%). By way of comparison, there was a comparable range among common indicators of concentrated advantage (Anderson, Leventhal, & Dupéré, 2014) in the sample of neighborhoods: the percentage of residents with Bachelor's degrees or higher ranged from 0-69% and the percentage of residents in managerial and professional positions ranged from 0-100%. These neighborhood level data suggest that there is substantial variability in the types of neighborhoods in which adolescent participants reside. This sample includes residents from neighborhoods characterized by concentrated affluence as well as residents of neighborhoods characterized by concentrated poverty and disadvantage, where large proportions of the populations are below the poverty line, are unemployed, or did not graduate high school. Neighborhood disadvantage was strongly negatively correlated (r=-.70) here with a measure of neighborhood advantage. Neighborhood disadvantage was also strongly negatively correlated with census measurement of median household income (r=-.77; median household income ranged from $0-$154,521 per year). These correlations support the conceptualization of low disadvantage neighborhoods being relatively socioeconomically advantaged. In the T1 sample the composite neighborhood disadvantage score ranged from -6.73 to 16.45 with a mean of zero.

Ethnic Concentration: Ethnic concentration is measured using the census variable reflecting the percentage of residents that are Hispanic/Latino (higher scores reflect a greater percentage of Hispanic residents), which ranges from 0-86.65%in the study sample (mean=21.47%). Of note, the percentage of non-Hispanic White residents ranges from 0-100% and correlates -.96 with percentage Hispanic/Latino, consistent with

the conceptualization of neighborhoods with low Hispanic/Latino concentrations as being homogenous White neighborhoods in the Southwestern region where this study was based.

Covariates

Gender. A dummy coded variable for gender was included as a covariate. 46.9% of adolescent participants at T1 were female and 53.1% were male.

Ethnicity. Adolescents' self-reported ethnicity was re-coded into a three category variable reflecting non-Hispanic Caucasian, Hispanic, or any other ethnicity. 59.3% of the T1 sample was Caucasian, 29% was Hispanic, and 11.8% belonged to any other ethnicity. Two dummy codes were included in all models to control for ethnicity.

Age. G3 age at T2 was calculated and included as a covariate to account for variability in age at the T2 interview. The mean age at T2 was 15.88.

Intelligence: G3 adolescents completed the Kaufman Brief Intelligence Test (Christakis & Fowler, 2009). The K-BIT score is a composite of standard scores on the verbal and nonverbal intelligence subtests and each individual's percentile rank score was included as a covariate in all models that included task measures of executive control. Intelligence percentile rank scores among the T1 task sample ranged from 1-98. Three cases had intelligence scores which fell into the impaired range, but there was no other indication of severe cognitive impairment from the interview. Thus, these three scores were assumed to be invalid estimates of actual youth intelligence and coded as missing. The final sample mean IQ of 60.4 was slightly higher mean percentile rank score than would be expected (50) in a normative population.

Biological parent Substance Use Disorder (SUD): DSM-IV criteria (American Psychiatric Association, 1994) and the computerized version of the Diagnostic Interview Schedule (Robins, Cottler, Bucholz, & Compton, 1995) were used to classify interviewed biological G2 parents of the G3 respondents as having or not having a lifetime alcohol or drug disorder diagnosis. Lifetime diagnosis was established for non-interviewed parents using spousal reports on the Family History Research Diagnostic Criteria (Andreasen, Endicott, Spitzer, & Winokur, 1977). Thus, all G3's with at least one biological parent with a lifetime history of alcohol or drug disorder diagnosis were classified as having a parental SUD. The majority of participants at T1 had at least one parent with a lifetime history of SUD (60.2%).

Family structure: G3s were categorized as living in a two-parent home or any other living situation, regardless of the biological relation of child to parent. The majority (76%) of participants at T1 lived in 2 parent homes.

T1 Substance use: Adolescents reported on their own lifetime use of all classes of substances at T1, yielding a count of the number of substances tried in their lifetime. The number of substances tried ranged from 0-6 (mean=.21, SD=.65). Only 12.3% of adolescents reported having initiated any alcohol or drug use by T1.

Substance Use Outcome

Initially, analyses were designed to model alcohol involvement and drug experimentation separately, in order to account for potentially unique relations with the two different types of substance use. However, given limited alcohol and drug use in the T2 sample and model convergence difficulties when alcohol and drug use were

differentiated, they were ultimately modeled as one construct: T2 substance use experimentation. T2 substance use experimentation was computed as a count of the lifetime number of substances tried (including alcohol, tobacco, marijuana, and seven other classes of illicit drugs). This method of operationalizing substance use is consistent with evidence that sensation seeking imparts risks for more in the early stages of experimentation and use rather than severity of abuse or dependence (Stautz & Cooper, 2013; C. A. Winstanley et al., 2010). The number of substances tried variable ranged from zero substances tried to 8 substances tried (mean= .73, SD=1.4). 70.3% of the sample (n=374) reported having tried zero substances at T2.

Data Analysis

Preliminary Analyses

Model diagnostics. All data were examined for out of range values, and SPSS outlier analyses and Normal Q-Q plots were inspected to assess the potential influence of outlying cases and whether variables were normally distributed. Skew and kurtosis statistics were also inspected. Descriptive statistics are included in Tables 4 and 5. These preliminary descriptive statistics revealed there were no extreme outliers that seemed problematic, but many study variables were characterized by non-normal distributions. Adolescent self-report of the number of substances tried at both T1 and T2 were the largest departures from normality. The count nature of the variables with a large number of zeros resulted in highly skewed and kurtotic distributions (T1 skewness=4.105, T1 kurtosis=20.639 ; T2 skewness=2.262 , T2 kurtosis=5.065). Zero-inflated Poisson (ZIP) modeling was employed in order to account for the non-normal count distribution with an

excess of zeros on the substance use experimentation outcome. ZIP modeling assumes that the zero counts observed in the sample result from two latent classes of individuals: "structural zeros" who are unable to assume any value other than zero (i.e. abstainers who will never report experimenting with substances) and a second latent class of individuals who have a zero score at T2 but also have some probability of assuming a non-zero count of substances tried (i.e. potentially higher risk youth who have not yet begun to experiment; Coxe, West, & Aiken, 2009). The ZIP models here estimated two regressions: a logistic regression which models the probability of being unable to assume any value other than zero (the structural zeros, a binary latent variable), and a second Poisson regression which predicts the value of the count of substances tried for those individuals in the latent class who are *able* to assume values of zero and above (excluding structural zeros). Non-normality was also addressed through MLR estimation which provides standard errors and test statistics robust to non-normality.

Correlations. Single-level zero-order correlations (Table 6) between all study variables revealed that, as hypothesized, T1 sensation seeking was significantly positively related to more T2 substance use experimentation. The relations between the hypothesized moderators and the T2 substance use outcomes, however, were less robust. Interestingly, one task indicator of executive control (working memory) was not significantly correlated with T2 substance use experimentation, and higher levels of spatial short term memory and response inhibition were correlated with higher rates of substance use experimentation at T2 (opposite the hypothesized direction). An investigation of partial correlations between executive control indicators, age, and

substance use revealed that the covariation of age and the executive control indicators is likely the cause of these counter-intuitive zero-order correlations. Once the strong effect of age on substance use is taken into account, working memory, response inhibition, and spatial short term memory are no longer significantly predictive of substance use. Parent report on survey effortful control and parents' report on their own parenting consistency were both significantly associated with less substance use experimentation at T2. Neighborhood disadvantage was positively associated with higher rates of T2 substance use experimentation, but neighborhood ethnic concentration was not significantly correlated with the T2 outcome.

Correlations between covariates and T2 substance use experimentation were largely consistent with what has been seen in the literature regarding risk for substance use: T1 rates of substance use and age at T2 assessment were both strongly positively correlated with T2 substance use experimentation. Being in any family structure other than a two parent household was associated with higher T2 substance use experimentation, as was having a biological parent with a substance use disorder. Higher income and higher intelligence were both associated with less T2 substance use experimentation. Interestingly, here non-Hispanic Caucasian ethnicity was associated with less T2 substance use experimentation. Gender, Hispanic ethnicity, and other ethnicity (not Hispanic or White) were not significantly correlated with T2 substance use experimentation.

Correlations between independent variables were also examined. As hypothesized, and consistent with confirmatory factor analyses, the task indicators of T1

executive control were all significantly correlated with each other in the hypothesized direction. T1 questionnaire executive control was also significantly correlated with task working memory, task response inhibition, and spatial short term memory and attention. Correlations did not suggest that multicolinearity among predictors was likely to be problematic.

Table 4
Individual Level Descriptive Statistics for Categorical Study Variables

Categorical Variable	N	%
Gender	*567*	*100*
Male	266	46.9
Female	301	53.1
Ethnicity	*566*	*100*
Non-Hispanic Caucasian	336	59.3
Hispanic	164	29.0
Other	67	11.8
Family Structure	*559*	*100*
2 Parent Family	425	75
Other Family Structure	134	24
Parent SUD	*555*	*100*
History of Parent SUD	334	60.2
No History of Parent SUD	221	39.8

Note. SUD= Substance Use Disorder

Table 5
Single Level Descriptive Statistics for Continuous Study Variables

Variable	N	Min.	Max	Mean	Std. Dev.	Skew	Kurtosis
T1 Sensation Seeking	522	1.00	5.0	3.02	.76	-0.27	.31
T1 Response Inhibition	347	.01	1.06	.60	.20	-.10	-.35
T1 Working Memory	377	1	19	10.19	2.50	-.79	2.94
T1 Spatial Short Term Memory	375	.14	.97	.56	.02	-.32	-.33
T1 Survey Executive Control	563	1.44	4.94	3.29	.68	0	-.47
T1 Parenting Consistency	522	1	5	4.04	.64	-.52	.59
T1 Neigh. Disadvantage	515	-6.73	16.45	0.00	3.77	1.09	.84
% below poverty line	515	0	46.59	8.86	7.76	1.36	2.10
% on public assistance	515	0	22.86	2.27	2.73	2.15	7.99
% not HS graduates	515	0	65.58	16.48	13.76	1.49	2.16
% female household head	515	0	69.52	20.72	9.89	1.05	2.33
% unemployed	515	0	14.83	4.03	2.75	1.01	1.27
T1 Neigh. Ethnic Concentration	515	0	86.65	21.47	20.83	1.40	1.09
T1 Substance Use	567	0	6	.21	.65	4.11	20.64
T2 Age at Assessment	534	10.94	20.98	15.88	2.44	.02	-.72
T1 Family Income (in $1000)	490	0	385	66.34	41.78	2.07	9.74
T1 Intelligence	374	4	98	60.40	23.67	-.41	-.73
T2 Substance Use	532	0	8	.73	1.41	2.26	5.07

Note. HS= High School. Neigh= Neighborhood.

Table 6
Neighborhood Level Descriptive Statistics

Variable	N	Min.	Max	Mean	Std. Dev.	Skew	Kurtosis
T1 Neigh. Disadvantage	275	-6.73	16.45	.26	3.92	1.05	.91
% below poverty line	275	0	46.59	9.34	8.28	1.36	2.00
% on public assistance	275	0	22.86	2.44	2.95	2.45	9.92
% not HS graduates	275	0	65.58	16.31	13.25	1.42	1.92
% female household head	275	0	69.52	10.70	10.70	.83	1.29
% unemployed	275	0	14.83	2.87	2.87	1.08	1.40
T1 Neigh. Ethnic Concentration	275	0	86.65	20.95	20.21	1.40	1.28

Note. N reflects the number of neighborhoods with census data. Neigh. =Neighborhood.

Table 7
Single Level Zero Order Correlations

	1. Sensation Seeking	2. Response Inhibition	3. Working Memory	4. Spatial STM & Attention	5. Survey Executive Control	6. Parenting Consistency	7. Neighborhood Disadvantage	8. Neigh. Ethnic Concentration	9. T1 Substance Use	10. Age at T2	11. Gender	12. Caucasian Ethnicity	13. Hispanic Ethnicity	14. Other Ethnicity	15. Family Structure	16. Parent Substance Use Disorder	17. Family Income	18. Intelligence	19. T2 Substance Use
1.	--																		
2.	-.031	--																	
3.	-.01	.29*	--																
4.	.02	.428*	.396*	--															
5.	-.32*	.24*	.247*	.196*	--														
6.	-.21*	.031	.111*	.03	.359*	--													
7.	.05	.05	-.10*	-.14*	-.04	-.15*	--												
8.	-.05	-001	-.18*	-.14*	-.04	-.16*	.664*	--											
9.	.179*	.179*	-.02	.02	-.10*	-.12*	.10	.08	--										
10.	.077	.442*	.133*	.327*	-.02	-.11*	-.01	.02	.339*	--									
11.	.05	-.162*	-.20*	.112*	-.13*	-.04	.07	.132*	-.07	-.08*	--								
12.	.112*	-.045	.082	.02	-.08	.077	-.26*	-.37	-.08	-.03	-.04	--							
13.	-.11*	.067	-.09*	-.03	.093*	-.07	.278*	.399*	.075	.03	.05	-.77*	--						
14.	-.02	-.025	.00	.01	-.02	-.02	.01	.00	.01	.01	-.02	-.44	-.23	--					
15.	.091*	.086*	-.06	-.08*	-.09*	-.12*	.192*	.108*	.138*	.02	-.04	-.08	.084*	.00	--				
16.	.087*	.054	-.13*	-.04	-.13*	-.18*	.184*	.108*	.169*	.142*	.00	-.14*	.099*	.08	.253*	--			
17.	-.05	.014	.149*	.117*	.07	.163*	-.33*	-.23*	-.09*	-.01	.00	.131*	-.13	-.02	-.35*	-.10*	--		
18.	.03	.179*	.464*	.321*	.227*	.082	-.15*	-.29*	-.12*	-.09*	-.10*	.246*	-.25*	-.03	-.08*	-.10*	.143*	--	
19.	.164*	.172*	-.01	.094*	-.15*	-.21*	.084*	.075	.578*	.453*	-.02	-.10*	.08	.04	.206*	.273*	-.12*	-.11*	--

Note. Correlations computed in Mplus. N=567. STM= Short Term Memory. Neigh. = Neighborhood.
*=$p \leq .05$

Analysis of Clustered Data Structure. Frequencies (Table 6) were computed for all study variables as estimates of the extent of clustering at both the family and neighborhood levels. In the full sample (N=567) there are a total of 530 cases with valid geocoded addresses. These 530 cases are distributed across 283 neighborhoods; there are an average 1.87 participants per neighborhood. The number of participants in a neighborhood ranges from 1-11. A total of 133 participants are the only participant from the current study in their neighborhood (singletons; 23.46% of the sample). At the family level, the 567 participants are distributed across 363 families; there is an average of 1.56 participants per family. 201 participants are singletons at the family level, comprising 35% of the sample. For the most part, families are nested within neighborhoods.

Table 8
Clustering Frequency

	# of Clusters	% of Clusters	% of Sample
Neighborhood			
Total Clusters	283		100
Residents without neighborhood: 37			6.5
1 resident	133	47.00	23.46
2 residents	95	33.57	33.51
3 residents	36	12.72	19.05
4 residents	8	2.83	5.64
5 residents	7	2.47	6.17
6 residents	1	0.35	1.06
7 residents	1	0.35	1.23
8 residents	1	0.35	1.41
9 residents	0	0	0
10 residents	0	0	0
11 residents	1	0.35	1.94
Family			
1 child	201	55.37	35.45
2 siblings	127	34.99	44.80
3 siblings	29	7.99	15.34
4 siblings	5	1.38	3.53
5 siblings	1	.28	.88

Methodological research suggests that the presence of singletons does not appear to be problematic for multilevel modeling in these analyses, as simulation studies show that problems typically only arise when the number of clusters is very small, around 50 (Bell, Morgan, Kromrey, & Ferron, 2010). Nevertheless, it is likely that the small number of cases per cluster and the overlap between family and neighborhood limit the ability to partition variability across both families and neighborhoods. In order to determine whether analyses needed to employ multilevel modeling at the family or neighborhood level, intra-class correlation coefficients were explored (Tables 8-9). The intra-class correlation coefficients were of comparable magnitude across the neighborhood and family levels.

Table 9
ICC's and Clustering at the Neighborhood Level

Variable	N	# Neighborhoods.	Avg. Cases/ Neighborhood	ICC
T1 Sensation Seeking	492	274	1.80	.18
T1 Response Inhibition	342	208	1.64	.06
T1 Working Memory	370	219	1.69	.10
T1 Spatial Short Term Memory/Attention	369	219	1.69	.27
T1 Survey Executive Control	528	282	1.87	.06
T1 Parent Consistency	492	274	1.80	.49
T1 Substance Use	530	283	1.87	.14
Age at T2	503	269	1.87	.12
Gender	530	283	1.87	.01
Caucasian Ethnicity (non-Hispanic)	530	283	1.87	.62
Hispanic Ethnicity	530	283	1.87	.60
Other Ethnicity	530	283	1.87	.03
Family Structure	523	280	1.87	.51
Parent Substance Use Disorder	524	281	1.87	.64
Family Income	469	261	1.80	.72
Intelligence	367	218	1.68	.33
T2 Substance Use Experimentation	501	269	1.86	.38

Table 10
ICC's and Clustering at the Family Level

Variable	N	# Families	Avg. Cases/ Family	ICC
T1 Sensation Seeking	523	348	1.50	.19
T1 Response Inhibition	376	275	1.37	.04
T1 Working Memory	377	275	1.37	.20
T1 Spatial Short Term Memory/Attention	375	275	1.36	.37
T1 Survey Executive Control	564	359	1.57	.05
T1 Parenting Consistency	523	348	1.50	.68
T1 Neighborhood Disadvantage	495	318	1.56	.95
T1 Neighborhood Ethnic Concentration	495	318	1.56	.97
T1 SU Experimentation	567	363	1.56	.53
Age at T2	314	242	1.30	.01
Gender	567	362	1.57	<.001
Caucasian Ethnicity (non-Hispanic)	567	363	1.56	.76
Hispanic Ethnicity	567	363	1.56	.83
Other Ethnicity	567	363	1.56	.12
Family Structure	559	359	1.56	.73
Parent Substance Use Disorder	556	354	1.57	.87
Family Income	490	328	1.5	.99
Intelligence	374	275	1.36	.42
T2 Substance Use Experimentation	532	342	1.56	.45

Investigation of ICC's revealed that parenting consistency had a large intra-class correlation coefficient at both the neighborhood (ICC= .49) and the family (ICC=.68) levels. This is not surprising given that the shared parent likely parents in similar ways across their children, and that some of the clustering at the neighborhood level is due to family members living together. It is also notable that the indicators of structural neighborhood organization all had very high ICC's at the family level (ICC's .95-.97), which again is consistent with family clusters largely residing in the same neighborhoods. The T2 substance use experimentation outcome also demonstrated a fairly high ICC at the neighborhood level (ICC= .38) and family cluster level (ICC=.45).

For many other variables the intra class correlation coefficients and design effects are quite low, falling well below a design effect cutoff of 2.0 that is sometimes considered negligible (Muthen & Satorra, 1995). Still, the clustered nature of the data was modeled using multilevel modeling, modeling level 2 variance at the neighborhood level, keeping in mind that neighborhood clustering also includes considerable clustering of siblings within the same neighborhoods. The use of multilevel modeling restricted the usable sample to those individuals with a valid, geocoded address (N=530).

Random slopes. Preliminary analyses included an assessment of whether the slopes of the focal study predictors on T2 substance use experimentation varied across neighborhoods, and the potential need to model these random slopes. A random slope model was estimated for each level 1 independent variable (sensation seeking, task executive control, survey executive control, and parenting consistency) and compared to a nested baseline model with fixed slopes. Likelihood ratio difference tests with scaling corrections for MLR estimation suggested that allowing a random slope did not significantly improve the model fit for sensation seeking, survey executive control, or parenting consistency predicting the T2 number of substances tried. The variability in task executive control across neighborhoods could not be exactly assessed because this test of the random slope failed to converge. Thus, primary analyses were conducted that did not include random slopes but did include random intercepts for all study variables.

Primary Analyses

The goal of this study was to examine the central hypothesis that individual and parent level controls, along with organized neighborhood environments, would prove

protective against sensation seeking's risk for adolescent substance use. All specific study questions were addressed using multilevel structural equation modeling in Mplus 7.2 using FIML to account for missing data and MLR estimation robust to non-normality (Muthén, 1998-2010). Interactions which reached at statistical significance ($p<.05$) were probed and plotted using the Johnson-Neyman technique for computation of regions of significance with confidence bands for the conditional effect (Johnson & Neyman, 1936; Preacher, Curran, & Bauer, 2006). All predictors included in interaction terms were grand mean centered (Aiken & West, 1991).

Covariates in all models included ethnicity, gender, baseline rates of substance use, age at T2, family income, family structure, and family history of SUD. Preliminary analyses tested potential covariate moderation of key paths, examining sensation seeking x covariate, moderator (executive control, parenting consistency, neighborhood organization) x covariate, and sensation seeking x moderator x covariate interaction effects on adolescent substance use for each covariate separately. Given the multiple un-hypothesized comparisons involved in testing these covariate x predictor interactions, significance levels were corrected for false discovery rates (FDR). FDR corrections were chosen because they are less conservative than Bonferroni corrections, have a greater power to detect truly significant results, but still maintain adequate control of Type 1 error rates (Benjamini & Hochberg, 1995). These analyses revealed that no interaction reached FDR-corrected significance levels, and thus all covariate x predictor interactions were dropped from primary analyses models.

The T2 substance use experimentation outcome was modeled in two parts: the zero-inflation portion of the outcome is a logistic regression predicting the likelihood of being a latent structural zero (an abstainer), while the Poisson portion models the count of number of substances tried among the latent class of individuals who were able to assume non-zero values.

Research Question1: **Dual Process Interactions.** Research question 1 was addressed with structural equation modeling (SEM) with pathways from T1 sensation seeking and executive control to T2 self-reported substance use experimentation, with an interaction between sensation seeking and executive control included in the model to test dual process moderation. Two parallel models were estimated, one including the questionnaire measure of executive control (see Figure 1a) and the other including a latent task executive control factor (indicators response inhibition, working memory, spatial short term memory; see Figure 1b). T1 adolescent IQ was included as an additional covariate in the model of task executive control moderation to account for the possibility that task executive control effects on T2 substance use experimentation might be due to general intelligence rather than a specific executive control effect. No neighborhood level covariates were included, but the neighborhood level mean and variance of the T2 number of substances tried outcome were estimated.

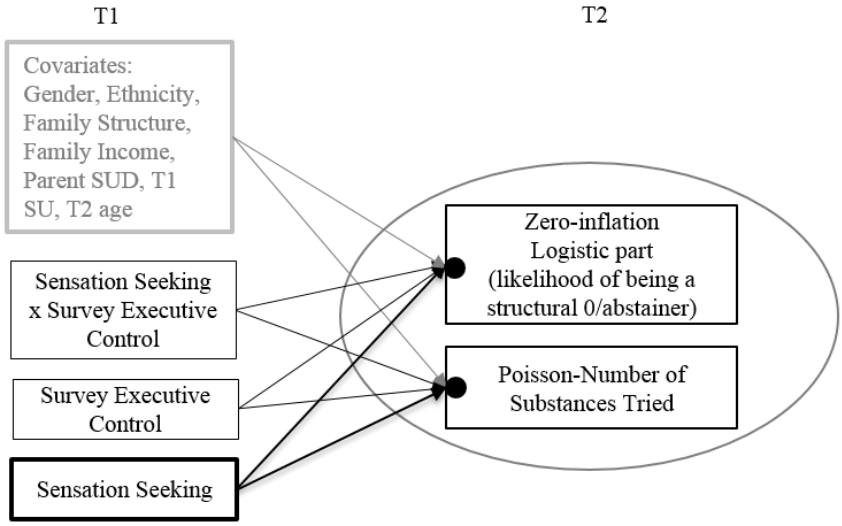

Figure 1a. Survey executive control model tested. Black dots indicate random intercepts allowed to vary across neighborhood clusters.

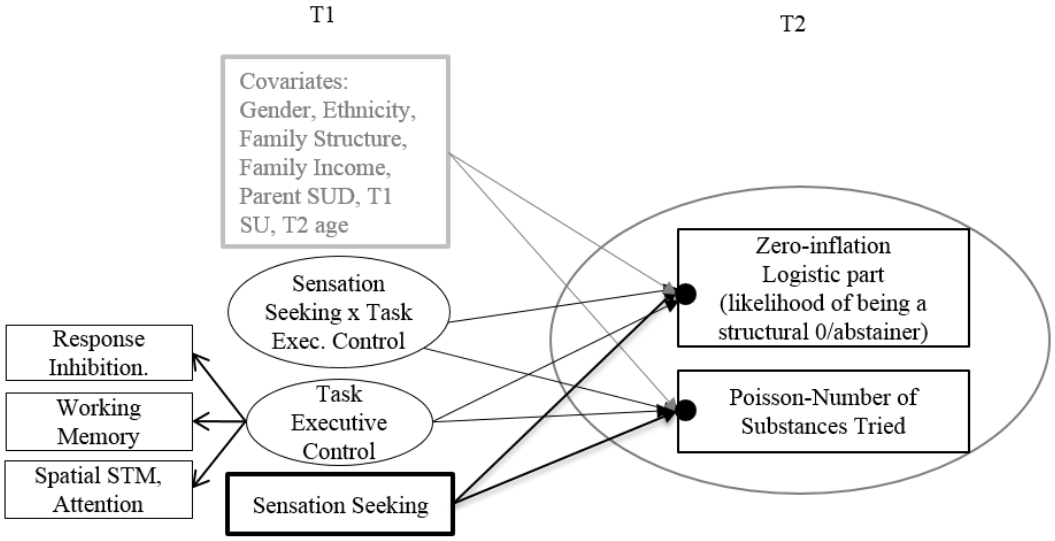

Figure 1b. Task executive control model tested. Black dots indicate random intercepts allowed to vary across neighborhood clusters. STM= Short-Term Memory.

Research Question 2: Parental Protection. Research question 2 was addressed using multilevel SEM with pathways from pathways from T1 sensation seeking and parenting consistency to T2 self-reported substance use experimentation, with an

interaction between sensation seeking and parenting consistency included in the model to test whether parental controls can attenuate the risks imparted by sensation seeking (see Figure 2). No neighborhood level covariates were included, but the neighborhood level mean and variance of the T2 number of substances tried outcome were estimated.

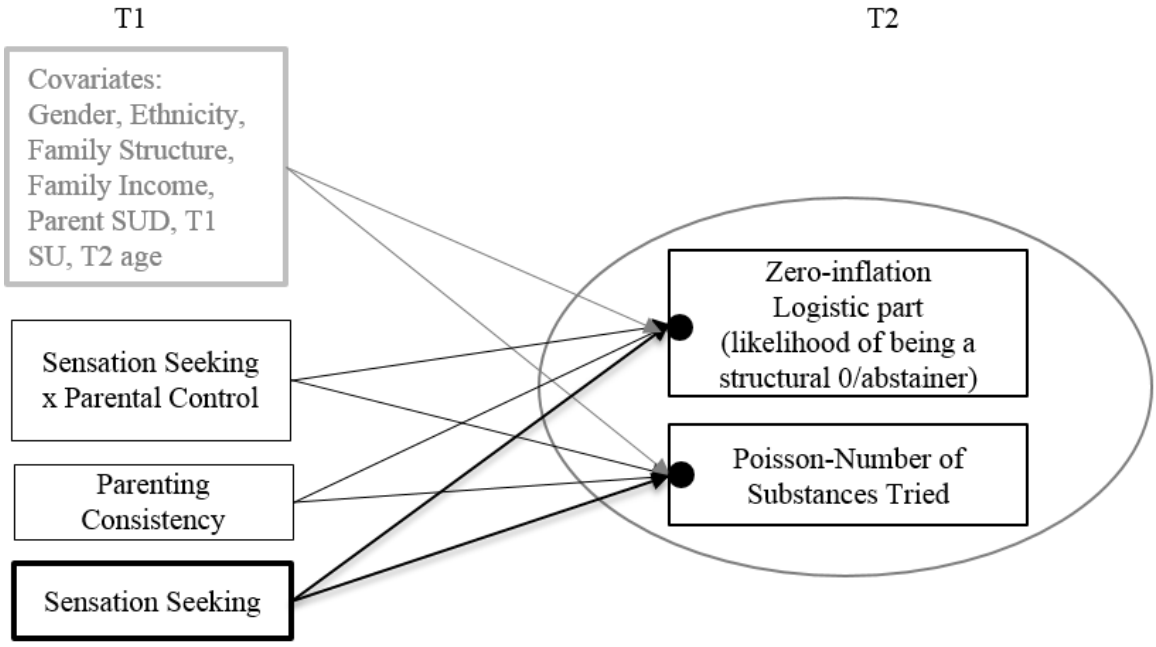

Figure 2. Parenting Consistency model tested. Black dots indicate random intercepts allowed to vary across neighborhood clusters.

Research Question 3: Neighborhood Protections. Research Question 3 was addressed in two separate multilevel SEM (see Figure 3). The first model included level 1 (within neighborhood cluster) relations between sensation seeking and T2 substance use experimentation alongside all covariates. At level 2 (between neighborhood clusters) neighborhood disadvantage and its square were regressed on the zero-inflated Poisson T2 substance use experimentation outcome. The inclusion of the squared term allowed for a

test of the hypothesized quadratic relation between neighborhood disadvantage and substance use experimentation such that both high and low levels of disadvantage (representing the most disadvantaged and advantaged communities, respectively) would be associated with increased risk for more substances tried and a lower likelihood of being an abstainer. The cross-level interactions between sensation seeking and neighborhood disadvantage were tested using the "define" command in Mplus to create two interaction terms: sensation seeking x neighborhood disadvantage (a linear interaction term) and sensation seeking x neighborhood disadvantage squared (a quadratic interaction term). These interaction terms were included in the level 1 (within neighborhood) portion of the model because the products of the level 1 variable (sensation seeking) and level 2 variables (neighborhood disadvantage and its square) vary within neighborhood clusters and thus behave as a level 1 variable. The inclusion of the quadratic interaction allowed for a test of the hypothesis that both highly disadvantaged communities and relatively more advantaged communities would represent risky environments which would facilitate the expression of sensation seeking risk for increased substance use experimentation.

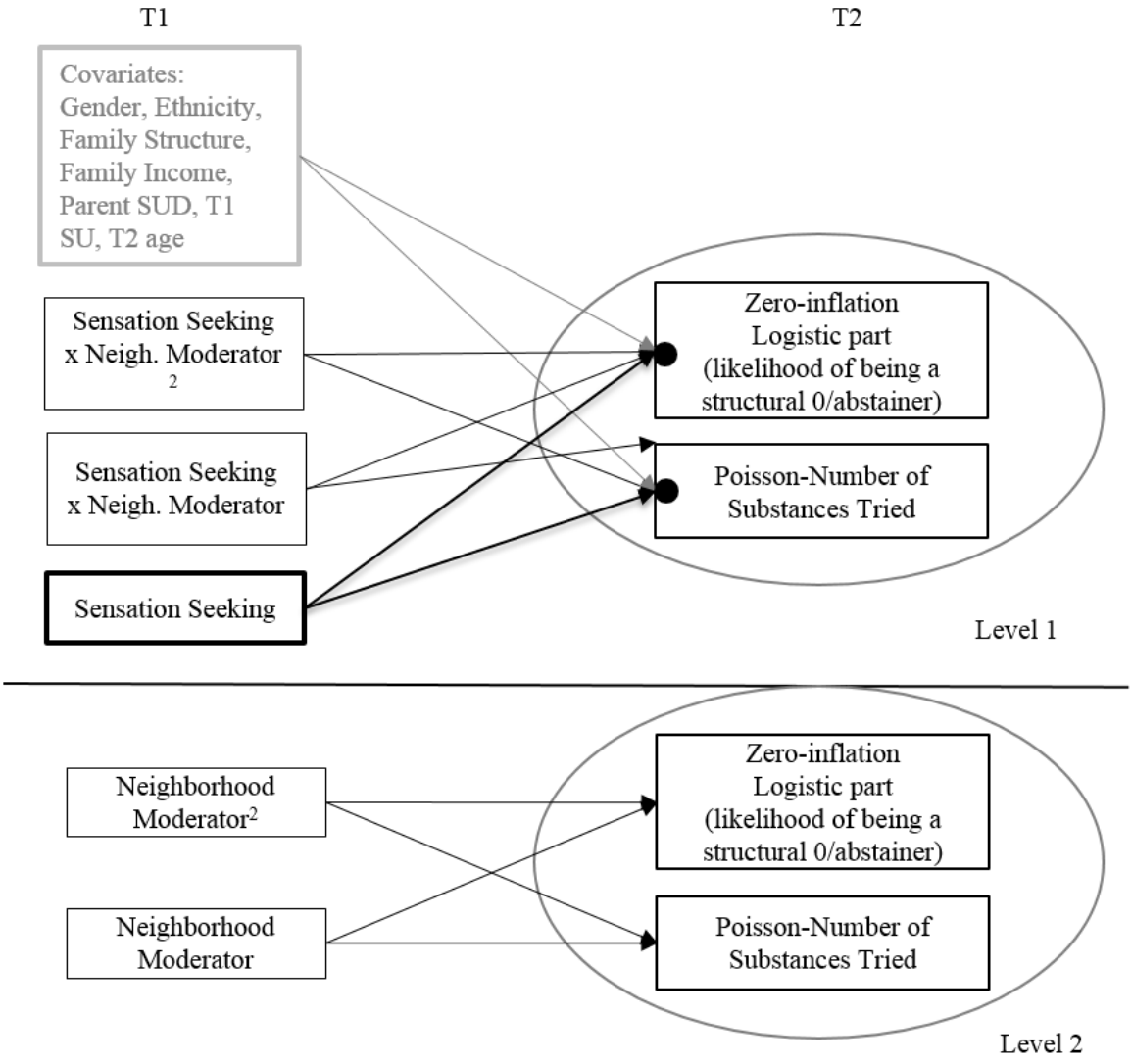

Figure 3. Neighborhood organization models tested. Neighborhood disadvantage and neighborhood ethnic concentration were included as the neighborhood moderators in two separate models. Black dots indicate random intercepts allowed to vary across neighborhood clusters.

A parallel two-level model was estimated for neighborhood ethnic concentration. In this model the inclusion of the quadratic main effect of neighborhood ethnic concentration tested the social disorganization hypothesis that both those neighborhoods with high concentrations of Latino residents (homogenous Latino communities) and those

neighborhoods with low concentrations of Latino residents (homogenous white communities) would be associated with decreased risk for substance use experimentation compared to the riskier ethnically heterogeneous communities in between these two extremes. The inclusion of the quadratic interaction between sensation seeking and neighborhood ethnic socialization allowed for a test of the hypothesis that both homogenous Latino communities and homogenous white communities would buffer against sensation seeking's risk for substance use experimentation.

Research Question 4: Additive Protections and Risk. The final model was intended to build upon the analyses conducted in service of Research Questions 1-3, and test whether those individual, family, and neighborhood factors that moderated sensation seeking's effect on adolescent substance use experimentation were still protective once the other factors and their moderating effects were taken into account. Given the power demands associated with these analyses including multiple interaction terms, this exploratory hypothesis was tested in a model building fashion, including only those terms (direct, curvilinear, and interactions) that emerged as significant in the first three research questions.

Results

Consistent Effects Across all models

A common set of covariates (gender, ethnicity, family structure, family income, parental SUD, T1 substance use experimentation, age at T2 assessment) was included across all models, and overall covariate effects on T2 substance use experimentation were quite consistent. Covariate effects, standard errors, and *p* values from all models can be

found in the Tables 1-4. Gender and ethnicity were not significantly associated with the counts or zero inflation portions of the substance use experimentation outcome in any model. Family structure was significantly related to the counts portion of the T2 substance use experimentation outcome, such that being in a non-two parent household was associated with significantly more substances tried by T2, though family structure was not significantly related to the odds of being an abstainer in the zero inflation portion of the models. Higher family income significantly predicted higher odds of being an abstainer across all models, but was not significantly related to the count number of substances tried, although in the survey executive control and parenting consistency models, family income was marginally significantly related to a higher count of substances used. Across all models having a biological parent with a substance use disorder was associated with a lower likelihood of being an abstainer from substance use; this association reached the level of statistical significance in all models except the task executive control model where the effect reached only marginal significance (β=-1.56, SE_β =.924, p=.092). Parental SUD was not statistically significantly associated with higher counts of substances tried in any model, though it was marginally significantly ($p \leq .10$) related to more substances tried in the parenting consistency, neighborhood disadvantage, and neighborhood organization models. The number of substances tried at T1 was consistently and significantly associated with a lower likelihood of being an abstainer and a higher number of substances tried at T2. The age at which youth completed the T2 assessments was also strongly and significantly related T2 substance use; older youth were less likely to be abstainers and had tried more substances.

In preliminary analyses which included all covariates mentioned above and the main effect of focal predictor sensation seeking, sensation seeking was associated with significantly lower odds of being an abstainer (β =-.681, SE_β =.212, p=.001) but was not significantly associated with the count number of substances tried by T2 (β =-.019, SE_β =.078, p=.809).

Research Question 1: Executive Control Moderation

The results of the test of executive control moderation are included in Table 10.

Survey Executive Control. The interaction between sensation seeking and survey executive control was not statistically significantly related to the likelihood of being an abstainer in the zero-inflation portion of the model, nor was survey executive control directly related to the likelihood of being an abstainer (at mean levels of sensation seeking). At mean levels of survey executive control, sensation seeking was significantly predictive of a lower likelihood of being an abstainer.

In the counts portion of the model, the interaction between sensation seeking and survey executive control was statistically significant. When the slope of sensation seeking on the count number of substances tried was plotted across levels of the moderator survey executive control (ranging from 1.5 SD above and below the mean; see Figure 4), results revealed that the slope was non-significant across this entire range of survey executive control. Sensation seeking was only significantly associated with the count of number of substances tried at the very upper range of survey executive control, where it was statistically negatively predictive of the number of substances tried, such that at extremely high levels of survey executive control higher sensation seeking was

associated with a lower number of substances tried. At below-mean levels of executive control the relation between sensation seeking and the number of substances tried was in the hypothesized direction, but did not reach the level of statistical significance.

Task Executive Control. The interaction between sensation seeking and task executive control was not statistically significantly related to the likelihood of being an abstainer in the zero-inflation portion of the model, nor was task executive control directly related to the likelihood of being an abstainer (at mean levels of sensation seeking). At mean levels of task executive control, sensation seeking was significantly predictive of a lower likelihood of being an abstainer. In the counts portion of the model, sensation seeking, task executive control, and their interaction were all non-significant in their associations with the count of number of substances tried at T2. Adolescent intelligence was significantly predictive of a higher count number of substances tried but unrelated to the likelihood of being an abstainer.

Table 11
Results of Executive Control Moderation

	T2 Substance Use Experimentation					
	Zero Inflation			Count		
IV	β	SE	*p* value	β	SE	*p* value
Survey Executive Control Moderation						
Gender	.331	.382	.386	.143	.142	.316
Caucasian Ethnicity	1.149	.732	.117	.060	.220	.786
Hispanic Ethnicity	.307	.782	.694	.002	.222	.994
Family Structure	-.109	.409	.789	.360**	.123	.003
Family Income	.014*	.007	.040	.003†	.001	.055
Parental SUD	-1.000*	.461	.030	.305	.187	.103
T1 SU	-1.603*	.680	.018	.219***	.044	<.001
Age at T2	-.600***	.119	<.001	.092**	.035	.008
Sensation Seeking	-.649**	.234	.006	-.067	.089	.448
Executive Control	.385	.309	.213	.110	.124	.373
SS x Exec. Control	.002	.277	.994	-.184*	.083	.027
Task Executive Control Moderation						
IQ	.028	.017	.108	.009*	.004	.018
Gender	.029	.533	.957	.077	.177	.664
Caucasian Ethnicity	1.269	.892	.155	.048	.238	.841
Hispanic Ethnicity	.634	.928	.494	.010	.250	.967
Family Structure	-.222	.455	.626	.399**	.133	.003
Family Income	.011	.007	.100	.003†	.002	.094
Parental SUD	-1.324*	.580	.022	.285	.211	.177
T1 SU	-1.688*	.671	.012	.292***	.054	<.001
Age at T2	-.711***	.212	.001	.045	.046	.332
Sensation Seeking	-.919**	.313	.003	-.071	.087	.412
Executive Control	.437	4.333	.920	.100	1.138	.930
SS x Exec. Control	-2.377	3.522	.500	-.645	1.486	.664

Note. SS= Sensation Seeking. SU= Substance Use. SUD= Substance Use Disorder. Exec.= Executive.
*** $p \leq .001$,**= $p \leq .01$, *=$p \leq .05$, †*=$p \leq .10$

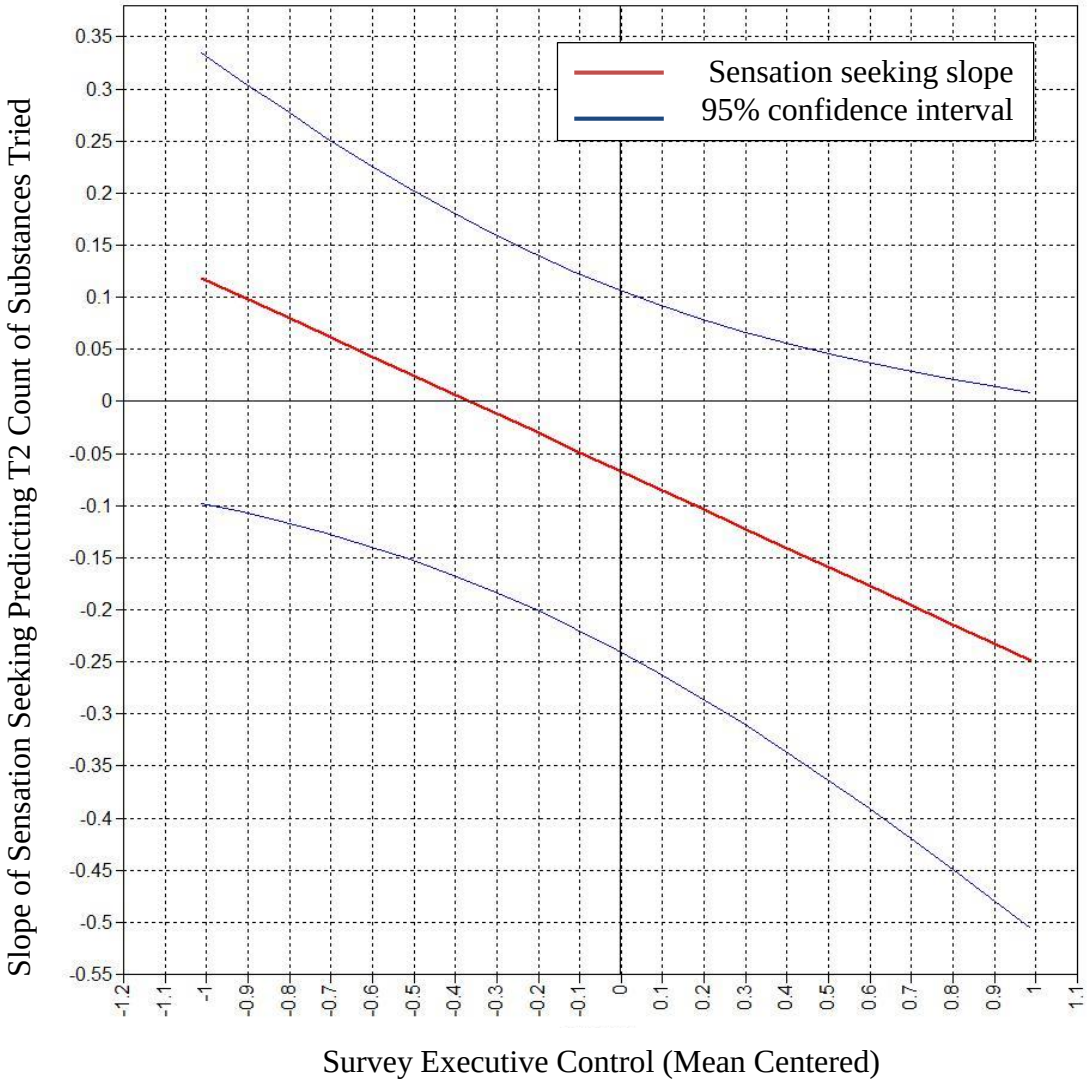

Figure 4. Plot of the slope of sensation seeking as a function of survey executive control predicting the T2 count number of substances tried. The range of survey executive control depicted here includes 1.5 SD above and below the mean, which includes about 86% of the sample.

Research Question 2: Parenting Consistency Moderation

Results of the test of Research Question 2 are depicted in Table 11. Contrary to hypotheses, parenting consistency had no direct or interactive effects on T2 substance use

experimentation. At mean levels of parenting consistency, sensation seeking was directly associated with lower odds of being an abstainer but unrelated to the T2 count number of substances tried.

Table 12
Results of Parenting Consistency Moderation

	T2 Substance Use Experimentation					
	Zero Inflation			Count		
IV	β	SE	*p* value	β	SE	*p* value
Gender	0.422	0.400	0.291	0.223†	0.133	0.093
Caucasian Ethnicity	0.892	0.742	0.230	-0.060	0.230	0.793
Hispanic Ethnicity	0.180	0.779	0.818	-0.164	0.245	0.502
Family Structure	-0.079	0.449	0.860	0.356**	0.136	0.009
Family Income	0.013*	0.006	0.044	0.002†	0.001	0.069
Parental SUD	-0.968*	0.495	0.050	0.354†	0.193	0.067
T1 SU	-1.680*	0.852	0.049	0.231***	0.042	<.001
Age at T2 assessment	-0.559***	0.116	<.001	0.103**	0.036	0.005
Sensation Seeking	-0.704**	0.234	0.003	-0.054	0.082	0.515
Parenting Consistency	0.707	0.446	0.113	-0.043	0.136	0.753
SS x Par. Consistency	-0.162	0.368	0.659	-0.153	0.124	0.217

Note. SS= Sensation Seeking. SU= Substance Use. SUD= Substance Use Disorder. Par. = Parenting.
*** $p \leq .001$,** = $p \leq .01$, * = $p \leq .05$, †* = $p \leq .10$

Research Question 3: Neighborhood Organization Moderation

Results of tests of moderation by neighborhood disadvantage and neighborhood ethnic concentration are depicted in Table 12.

Neighborhood Disadvantage

In the two level model including a test of curvilinear moderation (see Figure 3), the quadratic interaction between neighborhood disadvantage and sensation seeking's linear effect on the zero-inflation portion of the T2 substance use experimentation outcome was significant, as was the lower order linear sensation seeking x neighborhood

disadvantage interaction. When the slope of sensation seeking was plotted across levels of neighborhood disadvantage (see Figure 5), the curve of the line (shown in red) revealed that the effect of sensation seeking on the neighborhood level likelihood of being an abstainer was significant and negative below the sample mean of neighborhood disadvantage such that more sensation seeking was a risk for a lower neighborhood level likelihood of being an abstainer. Above the mean of neighborhood disadvantage, the slope of sensation seeking predicting the neighborhood level likelihood of being an abstainer was still in the hypothesized negative direction, but did not reach statistical significance. Notably, as neighborhood disadvantage increased at the upper end of the range, the slope of sensation seeking predicting the neighborhood level likelihood of being an abstainer became more negative again, as it had in the more advantaged communities, though the slope did not reach statistical significant within 1.5 SD from the mean. Sensation seeking, neighborhood disadvantage, and their interactions (both quadratic and linear) were all non-significantly related to the T2 neighborhood level count number of substances tried.

Table 13

Results of Neighborhood Organization Moderation

	T2 Substance Use Experimentation					
	Zero Inflation			Count		
IV	β	SE	*p* value	β	SE	*p* value
Neighborhood Disadvantage Moderation						
Gender	.299	.354	.397	.170	.137	.214
Caucasian Ethnicity	.971	.665	.144	-.030	.214	.887
Hispanic Ethnicity	.322	.707	.649	-.111	.225	.622
Family Structure	-.087	.402	.828	.388***	.122	.001
Family Income	.013*	.006	.031	.002	.001	.153
Parental SUD	-1.050*	.479	.029	.323†	.190	.090
T1 SU	-1.652**	.595	.006	.247***	.037	<.001
Age at T2	-.582***	.110	<.001	.083*	.035	.019
Sensation Seeking	-.418	.265	.115	-.079	.102	.436
Neigh. Dis.	.036	.062	.559	-.013	.024	.599
Neigh. Dis. ^{2}	.001	.007	.918	-.001	.002	.779
SS x Neigh. Dis.	.161*	.076	.034	-.024	.029	.410
SS x Neigh. Dis.^{2}	-.025*	.011	.019	.005	.004	.165
Neighborhood Ethnic Concentration Moderation						
Gender	.286	.365	.433	.176	.140	.209
Caucasian Ethnicity	1.060	.746	.155	.011	.228	.963
Hispanic Ethnicity	.376	.817	.646	-.056	.262	.831
Family Structure	-.119	.397	.765	.352	.126**	.005
Family Income	.012*	.006	.035	.002	.001	.173
Parental SUD	-.997*	.460	.030	.346	.188	.065
T1 SU	-1.685*	.659	.011	.248	.041***	<.001
Age at T2	-.564***	.110	<.001	.087	.034**	.010
Sensation Seeking	-.777*	.327	.017	-.007	.093	.936
NEC	-.005	.017	.776	-.003	.007	.701
NEC^2	<.001	<.001	.812	.000	.006	.947
SS x NEC	.011	.015	.464	<.001	<.001	.959
SS x NEC^2	<.001	<.001	.991	<.001	<.001	.861

Note. SS= Sensation Seeking. Neigh. Dis= Neighborhood Disadvantage. NEC= Neighborhood Ethnic Concentration. SU= Substance Use. SUD= Substance Use Disorder.

*** $p \leq .001$,**= $p \leq .01$, *=$p \leq .05$, †*=$p \leq .10$

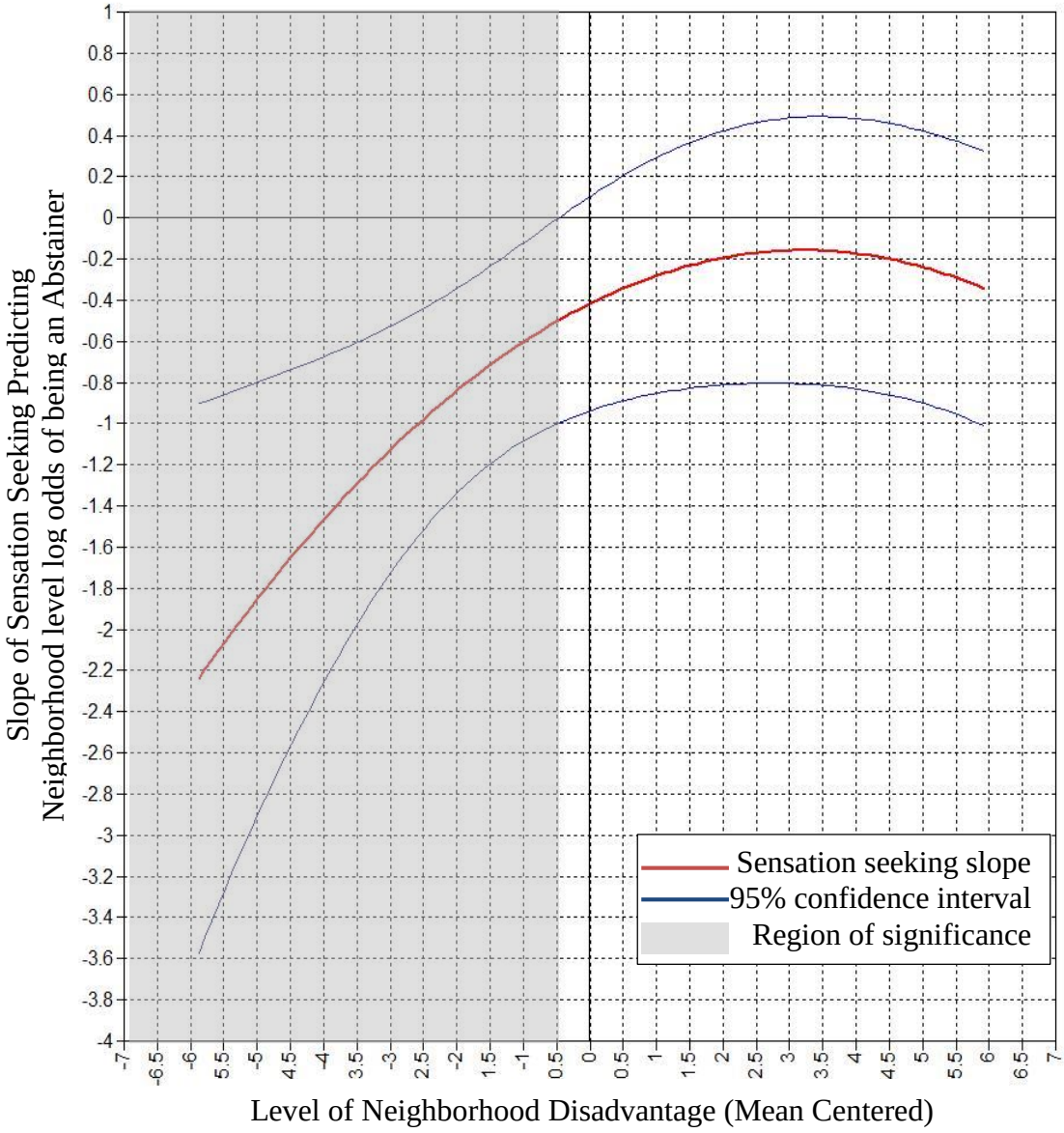

Figure 5. Plot of the slope of sensation seeking as a function of neighborhood disadvantage, predicting the zero-inflation portion of the substance use experimentation outcome. The range of neighborhood disadvantage depicted includes 1.5 SD above and below the mean of neighborhood disadvantage, and includes about 89% of the neighborhoods sampled.

Neighborhood Ethnic Concentration

Contrary to hypotheses, neighborhood ethnic concentration had no direct or interactive effects on T2 neighborhood level substance use experimentation. At mean levels of neighborhood ethnic concentration, sensation seeking was directly associated with lower odds of being an abstainer, but unassociated with the count number of substances tried by T2. [1]

Research Question 4: Additive Protections and Risk

The final exploratory additive protection model included all direct and interaction effects that emerged as significant in models 1-3. Thus, level 1 relations between sensation seeking, survey executive control, the sensation seeking x survey executive control interaction, the sensation seeking x neighborhood disadvantage linear interaction, and the sensation seeking x neighborhood disadvantage squared quadratic interaction were all regressed on T2 substance use experimentation. The level 2 model included neighborhood disadvantage and neighborhood disadvantage squared predicting T2 substance use experimentation. Consistent with the results of earlier models, the interaction between sensation seeking and survey executive control maintained its significance in the final additive model predicting the T2 count number of substances tried, and the simple slopes were of the same nature as those seen in

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[1] Potential ethnic differences in the strength of predictive relations are of particular interest in models of neighborhood effects. Unfortunately, general multiple group analysis is not available in Mplus for multilevel models when the grouping variable is at the within level (here ethnicity is an individual level grouping variable). Preliminary predictor by ethnicity interactions suggested a lack of ethnic differences for the effect of sensation seeking, neighborhood disadvantage and neighborhood ethnic concentration, or their interactions.

the simpler model of survey executive control moderation. Likewise, the cross-level quadratic interaction between sensation seeking and neighborhood disadvantage was again statistically predictive of the neighborhood level likelihood of being an abstainer, such that the least disadvantaged communities exhibited the strongest effects of sensation seeking on the neighborhood level odds of being an abstainer, and there was a trend towards increased sensation seeking risk in the most highly disadvantaged neighborhoods.

Table 14
Results of Additive Model

	T2 Substance Use Experimentation					
	Zero Inflation			Count		
IV	β	SE	*p* value	β	SE	*p* value
Gender	.436	.366	.234	.168	.136	.218
Caucasian Ethnicity	.995	.715	.164	-.003	.216	.991
Hispanic Ethnicity	.290	.738	.694	-.053	.219	.809
Family Structure	-.032	.412	.938	.404***	.119	.001
Family Income	.013*	.007	.046	.002†	.001	.091
Parental SUD	-.981	.470	.037	.288	.194	.138
T1 SU	-1.632**	.566	.004	.230 ***	.040	<.001
Age at T2 assessment	-.600***	.115	<.001	.085*	.034	.012
Sensation Seeking	-.311	.290	.284	-.113	.100	0.259
Survey Exec. Control	.450	.332	.175	.066	.133	.617
SS x Exec. Control	.043	.272	.159	-.204*	.097	.036
Neigh. Disadvantage	-.039	.066	.553	-.018	.027	.502
Neigh. Disadvantage ^{2}	<.001	.007	.986	<.001	.002	.893
SS x Neigh. Dis.	.183*	.077	.017	.003	.032	.925
SS x Neigh. Dis.^{2}	-.123***	.022	<.001	.003	.003	.397

Note. SS= Sensation Seeking. SU= Substance Use. SUD= Substance Use Disorder. Neigh Dis= Neighborhood Disadvantage.
*** $p \leq .001$,**= $p \leq .01$, *=$p \leq .05$, †*=$p \leq .10$

Discussion

The present study utilized multilevel longitudinal data to test several hypotheses about the risk for substance use imparted by sensation seeking, and whether individual, family, and neighborhood level factors could protect against this risk.

Sensation Seeking Risk.

Interestingly, the basic assumption of the hypotheses tested here, that sensation seeking imparts risk for substance use, was only partially supported. Sensation seeking was directly related to only the zero-inflation portion of the substance use experimentation outcome (tapping risk for initiation of *any* substance use) but was not predictive of increasing levels of involvement with multiple substance classes. This finding is somewhat consistent with the literature which has shown that sensation seeking is more consistently linked to *exploratory* substance use and initiation into use than more problematic use (Curcio & George, 2011; Stautz & Cooper, 2013; C. A. Winstanley et al., 2010). It is also possible that the lack of sensation seeking effects on the number of substances tried is due to the low number of individuals who reported using multiple substances, and thus a lack of statistical power to detect an effect among this smaller sample of youth. Future research in a larger sample of youth with more extensive substance use histories could help elucidate these potentially distinct pathways to substance use initiation, extent of experimentation, and potentially problematic use.

Dual-process Moderation.

Hypothesized dual-process interactions between sensation seeking and executive control were not supported, suggesting that here the interplay between hot and cold facets

of disinhibition was not influential for adolescent substance use experimentation. Task executive control did not moderate sensation seeking's effects on adolescent substance use experimentation, and survey executive control also failed to moderate sensation seeking's effect on the likelihood of being a substance use abstainer. There was a statistically significant interaction between sensation seeking and survey executive control predicting the count number of substances tried, however. The slope of sensation seeking on the count number of substances tried varied across levels of survey executive control, though the effect did not reach statistical significance within the interpretable range. There was a trend towards a negative relationship between sensation seeking and the count number of substances tried at the very highest ranges of survey executive control, which would suggest that sensation seeking is associated with *fewer* substances tried when executive control is very high. Notably, neither the latent task executive control factor nor survey executive control was directly related to substance use experimentation in path analyses results. This was somewhat surprising, given studies in which executive control is associated with less substance use in the literature (Giancola & Parker, 2001), but also consistent with the mixed results that have been seen regarding cold facets of disinhibition and substance use (Stautz & Cooper, 2013).

The role of age is a relevant one, given the lack of dual process moderation in the present study. Studies have repeatedly demonstrated that both sensation seeking and executive control are developing over the course of adolescence, and the mismatch between the developmental timing of these two systems can result in increases in adolescent risk taking (Steinberg, 2010; Steinberg et al., 2008). Early adolescence was

targeted in the present study as a critical period of development for both of these systems, but nevertheless there is considerable age heterogeneity in this sample even within this early adolescent period, and the brain maturation that takes place between the ages of 10 and 15 can be considerable. Dual process interactions as determinants of adolescent substance use would perhaps be better understood in future research using methods which take into account the changing nature of sensation seeking, executive control, and the dynamic interplay between the two. Growth modeling of the developmental trajectories of sensation seeking and executive control over time could evaluate whether greater discrepancies between these curves results in higher risk, and would extend past research which has shown that steeper increases in sensation seeking over late childhood/early adolescence result in higher risk for alcohol use, above the risk conferred by high levels of sensation seeking at a single static time point (MacPherson, Magidson, Reynolds, Kahler, & Lejuez, 2010).

Neither survey nor task executive control served to moderate sensation seeking effects. This could be due, at least in part, to the way in which executive control was operationalized in the present study. This study treated executive control as a single unitary construct, which is consistent with research suggesting that perhaps the sum of executive functioning is greater than its parts (Giancola & Parker, 2001). Others might argue, however, that a lack of significant findings here might be due to the aggregation of different facets of executive control which might have varying influences on the outcome. An examination of partial correlations revealed that even when pulled apart, response inhibition, working memory, and spatial short term memory and attention were

not directly related to adolescent substance use experimentation, which can strengthen one's confidence that it is not the latent factor that is obscuring relations from the indicators to adolescent substance use. Although these three dimensions of executive functioning are well-supported in the literature (Day, Kahler, Ahern, & Clark, 2015), there are certainly other aspects of executive functioning that together may prove more predictive of substance use and more protective against sensation seeking risk. A potential direction for future research might be an added focus on set shifting, which has been relatively neglected in the alcohol and drug abuse literatures but which may be relevant in substance use to the extent that individual's inability to switch back and forth between tasks might make it difficult to engage in coping strategies in the face of substance use cues (Day et al., 2015).

Parental Protection

The present study tested the hypothesis that consistent parental discipline and limit setting would buffer against sensation seeking's risks for substance use experimentation, perhaps by limiting opportunities for use and introducing consequences for use. Results did not support this interactive hypothesis, nor was parenting consistency directly related to adolescent substance use initiation. Although parenting consistency has theoretical appeal as a moderator of sensation seeking risks, this null finding is consistent with other studies in early adolescence (Stephenson & Helme, 2006) and early adulthood (Kaynak et al., 2013) which have failed to support the role of parental controls as moderators of sensation seeking risks for substance use behaviors. Given the focus of the present study on individual and contextual controls that could protect against sensation

seeking risk, these analyses tested only the restrictive elements of parenting, but ignored the benefits of warm, caring parent-child relationships that have also been seen in the literature (K. M. King & Chassin, 2004). Future studies focusing on how close relationships might reduce the risks imparted by a sensation seeking temperament would potentially explicate alternate ways that parents can protect their children from the consequences of substance use, even in the face of high dispositional risk.

One possible reason for the failure of parent consistency to buffer the effects of sensation seeking is that parent consistency was measured by parent report rather than child report. Reporters of T1 moderators were chosen to avoid shared method variance, which would differentially bias some predictors over others. It is possible that parents' responses were affected by a pull for socially desirable responding, and even a potential ceiling effect. Adolescents might also be more likely to be impacted by how they perceive their caregivers' parenting than how consistent the parent perceives him or herself to be. This is consistent with other studies showing differential effects of parent and child report, and more predictive utility of child perceptions of parenting as determinants of substance use (Chassin et al., 2005; Tein, Roosa, & Michaels, 1994). A direction for future research would be to utilize children's report on their caregivers' parenting consistency in hope that it might yield more accurate data on the extent to which parents consistently enforce rules and consequences in the home.

Neighborhood Moderation

The hypothesized role of two different facets of neighborhood organization (disadvantage and ethnic concentration) as moderators of sensation seeking effects on adolescent substance use experimentation was partially supported.

Neighborhood disadvantage and sensation seeking did not interact in predicting the number of substances tried by adolescents, but, as hypothesized, neighborhood disadvantage did serve to moderate sensation seeking's effects on substance use initiation in a non-linear manner. Neighborhood disadvantage was not directly related to substance use. Rather, neighborhood disadvantage impacted how sensation seeking risk for substance use was expressed. Across all levels of disadvantage, the direction of sensation seeking's effect was such that it was associated with greater risk of initiating substance use, but this effect was only significant in neighborhoods with below-average levels of disadvantage. That is, as neighborhood disadvantage decreased from average levels, sensation seeking had a stronger impact on the likelihood of initiating substance use; sensation seeking was riskiest in the most advantaged communities. In those neighborhoods with mean levels of disadvantage and higher, sensation seeking's effect on initiation of substance use was non-significant. Notably, the quadratic interaction indicated that at the highest levels of disadvantage, the risk for substance use initiation imparted by sensation seeking began increasing again, as it had in the more advantaged communities.

Zimmerman (2010) has previously demonstrated a relevant finding for delinquency, showing that impulsivity was only associated with higher risk of offending

in the least socioeconomically disadvantaged neighborhoods, but not those characterized by high and mean levels of disadvantage. Zimmerman asserts that this finding is consistent with the idea that dispositional traits will be suppressed in more criminogenic environments, but that in advantaged, less criminogenic communities, individual vulnerabilities will be allowed to express themselves. This argument, that disadvantaged communities are so risky that they crowd out individual level risks, has some weaknesses, however. In Zimmerman's 2010 study, as here, neighborhood socioeconomic disadvantage was not directly associated with the outcomes. That is, at average levels of individual/dispositional risk, there were no differences between disadvantaged communities, average communities, and advantaged communities on crime and substance use. Likewise, several recent systematic reviews have concluded that, although substance use does seem to cluster geographically, neighborhood disadvantage is not consistently the causal culprit for this clustering (Bryden et al., 2013; Jackson et al., 2014; Karriker-Jaffe, 2011). This lack of differences across levels of disadvantage makes it difficult to argue that highly disadvantaged neighborhoods pull for higher levels of delinquency and substance use, because they don't actually demonstrate higher levels of risk.

This raises the question, then, what is it about the relatively more advantaged communities in the present study that facilitates the expression of sensation seeking risk for substance use initiation, and conversely, what is it about average and, to some extent, highly disadvantaged neighborhoods that is protective against sensation seeking risk? Perhaps the most straightforward mechanism that might account for increased sensation

seeking effects on substance use initiation is availability. Community levels of drinking and availability of drugs and alcohol are consistently shown as risk factors for individual substance use (Bryden, Roberts, McKee, & Petticrew, 2012; Bryden et al., 2013; Jackson et al., 2014). Perhaps youth from more advantaged communities are presented with more opportunities to initiate substance use through their own and their peers' economic ability to buy alcohol or drugs. However, it is notable that individual family income levels were actually associated with *less* substance use initiation in the present analyses, which would suggest that economic means to purchase may not be the only answer.

Luthar has posited two primary mechanisms for increased risk for substance use among affluent youth: pressure to achieve and isolation from adults (Luthar & Latendresse, 2005a). Youth from advantaged communities are often pushed to participate and perform in multiple scholastic and extracurricular domains, which can lead to drinking and using substances to alleviate stress and distress (Luthar & Becker, 2002; Luthar & Latendresse, 2005a). This internalizing pathway to substance use, characterized by comorbidities with anxiety and depression, is more common among affluent youth than among youth from low income communities, where using substances to cope is less common (Luthar & Latendresse, 2005a). The results of the present study, however, suggest that an alternate *externalizing* pathway from sensation seeking tendencies to substance use experimentation may also be at work in relatively more advantaged communities. Isolation from adults could potentially influence this externalizing pathway as well; it could be that large amounts of time spent alone results in increased unsupervised opportunities for use as well as less fear of damaging an already distant

parent-child relationship by breaking the rules. Isolation from adults, both emotionally and in a supervisory capacity, may also characterize the highest end of the neighborhood disadvantage dimension. Research has suggested that both very affluent and impoverished communities suffer from comparably low levels of closeness and time spent with parents (Luthar & Latendresse, 2005b). This isolation from adults could potentially contribute to similarities in opportunities for the expression of sensation seeking risk among both the most and least disadvantaged communities.

Another potential mechanism for increased risk in more advantaged communities might be differential perceptions of consequences of substance use. Disadvantaged, inner city, and minority communities see considerably higher levels of drug-related arrests and convictions than higher SES communities, despite having comparable levels of substance use (J. Fagan & Meares, 2008; Project Know, 2015). This may contribute to a normative fear of legal consequences for substance use in more disadvantaged communities that does not exist in better-off neighborhoods. If teens in more advantaged areas perceive (sometimes correctly) that there are fewer consequences for substance use experimentation, they may be more likely to initiate. Perhaps the threat of legal repercussions is more salient in average and disadvantaged communities, and thus even the most sensation seeking individuals reel in their desire for fun for fear of negative consequences. It has been suggested that perhaps affluent youth can dabble in substance use and experience less damage to their life prospects, due to factors like concerned adult advocates and even access to high quality treatment services should the need arise (Luthar & Sexton, 2004). A certain degree of substance use experimentation in

adolescence is quite common, even normative, and adolescents from better-off communities may perceive experimentation as harmless in a way that youth from more disadvantaged communities cannot.

Neighborhood ethnic concentration was not associated with substance use, nor did it moderate sensation seeking risk for substance use experimentation. Although some research has shown that high Latino and immigrant concentrations can benefit community members from all cultures (A. A. Fagan et al., 2015), other research has suggested that Latino individuals may benefit more from residing in co-ethnic communities with high concentrations of other Latinos (Molina et al., 2012). A multigroup model testing for ethnic differences on all paths was precluded here by multilevel modeling constraints and subgroup sample sizes, but preliminary examination of predictor by ethnicity interactions suggested a lack of ethnic differences for the effect of sensation seeking, neighborhood ethnic concentration, or their interaction. Future studies should investigate the hypotheses tested here in a larger sample with a higher proportion of Latino residents (with enough power for subgroup analyses) and/or in an ethnically homogenous Latino sample to better understand how concentrations of Latino residents impact substance use among Latinos specifically.

It is worth mentioning that in this study, as in most studies of neighborhood structural characteristics, neighborhood disadvantage is highly conflated with neighborhood level race/ethnicity. The most disadvantaged neighborhoods are also the most diverse, and the most advantaged neighborhoods are predominantly white. A strength of this study is that the null test of neighborhood ethnic concentration effects

can, to a certain extent, address this potential confounding of neighborhood disadvantage effects, as can the fact that individual level race/ ethnicity was controlled for in all models. Nonetheless, it is important to consider that those relatively more advantaged neighborhoods which saw greater sensation seeking risk for substance use initiation were also more likely to be white neighborhoods. Norms for abstinence among certain cultural subgroups may also help explain why the relatively more advantaged communities here saw more sensation seeking risk. Communities and families comprised of individuals with higher levels of religiosity, for instance, are much more likely to promote complete abstinence from substance use, as has been seen in low income African American and Hispanic populations (Hodge, Marsiglia, & Nieri, 2011; Wallace, Brown, Bachman, & LaVeist, 2003). In contrast, affluent communities seem to be characterized by high parental tolerance of substance use and acceptance of some use as normative (Luthar & Goldstein, 2008). Thus, it is likely that considerably different norms around substance use and substance abstinence exist in high and low disadvantage neighborhoods.

As mentioned above, there was substantial age heterogeneity in the sample, which was particularly relevant to maturation of sensation seeking and executive control over the course of adolescence. Age of assessment is also relevant for the examination of neighborhood hypotheses and substance use. Early adolescence was chosen for the first time point not only because it is the appropriate developmental period for the onset of substance use, but also because early adolescence is when youth first begin to autonomously explore their neighborhood environments and likely be influenced by them. The literature supports this decision to focus on early adolescent neighborhood

environments as the nexus between childhood restricted access to the community alone and older adolescent ability to leave the neighborhood and navigate other spatial domains (Jackson et al., 2014). A related issue is that a developmental/prospective assessment of neighborhood was chosen as a predictor of future substance use. The temporal ordering of these assessments strengthens this study's ability to make causal interpretations of the results, but also raises the question of whether an assessment of contemporaneous neighborhood disadvantage and ethnic concentration would be more relevant to substance use; would where one *currently* lives better predict his/her *current* substance use? An avenue for future exploration is an examination of these cross-sectional neighborhood relations and a comparison with prospective models.

Future research is needed to further elucidate the mechanisms through which neighborhoods influence sensation seeking's impact on adolescent substance use initiation. New analytical technologies will likely prove vital in this endeavor; geospatial modeling technologies could potentially allow investigators to overlay spatially-coded data about neighborhood socioeconomic conditions, drug-related arrests, and even alcohol (and increasingly marijuana) outlet density. Ecological momentary assessment methods, ongoing geolocation, and other methods for assessing the diverse activity spaces within which adolescents operate will also aid in the study of complex neighborhood effects which go beyond static address-based methods (Browning & Soller, 2014).

Additive Protections and Risk

Only neighborhood disadvantaged emerged as a meaningful moderator of sensation seeking effects, which did not allow for testing hypotheses about additive effects. A criticism of studies of neighborhood processes is that they sometimes over-control for potential confounds which may in fact be mediators of neighborhood effects on substance use, and thus can potentially obscure important neighborhood effects (Jackson et al., 2014). Relevant here, some research has indicated that characteristics of the neighborhood context can impact both self-control and parenting (Gibson, Sullivan, Jones, & Piquero, 2009; Pinderhughes, Nix, Foster, & Jones, 2001), which underscores the importance of not including neighborhood effects and potential mediators together without testing for mediation statistically. The present study addressed this possibility by first testing the effects of executive control, parenting consistency, and their interactions with sensation seeking in separate models from the test of neighborhood moderation. This approach can strengthen one's confidence that a lack of effects was not due to a "washing out" from including all predictors and interaction terms in the same model at once.

Limitations, Strengths, and Conclusions

As described earlier, this study has several limitations. Most notably, the sample was characterized by low rates of substance use experimentation, which limited the study's ability to detect effects on the number of substances tried. This limitation is tied to the age constraints of the present sample, which followed youth from T1 in early adolescence (ages 10-15) to a follow up 1.5-3 years later. This age band resulted in some

youth still being quite young at the second time point and thus unlikely to have initiated any use. This study was also limited in its ability to test and detect racial and ethnic differences in the moderated effects of sensation seeking on substance use experimentation. Lastly, the study was limited by the extent to which it could model changes in sensation seeking, executive control, and even neighborhood residence across time. Examining the research questions posed here in an older, larger, more diverse longitudinal sample with more extensive substance use histories remains an important direction for future research.

Despite these weaknesses, this study also had considerable strengths that enable it to make an important contribution to existing research on sensation seeking risk for substance use. First, this is one of very few studies to examine the interplay between sensation seeking and individual, family, and neighborhood level factors, and the only known study to examine multiple levels of moderation of sensation seeking effects on substance use specifically. Another strength of this study was that it utilized the appropriate multilevel modeling techniques to estimate cross-level interactions between individual sensation seeking and neighborhood level disadvantage and ethnic concentration. This modeling strategy greatly reduced the likelihood of Type I errors which result from using single-level methods with clustered data, and resulted in a conservative test of research questions. The present study was also greatly strengthened by its ability to examine non-linear moderation of sensation seeking's effects, extending prior work which has attempted to approximate neighborhood moderation of disinhibition effects using linear moderation models or logistic regression dividing the sample into

discrete groups by level of disadvantage (Barker et al., 2011; Vazsonyi et al., 2006; Zimmerman, 2010). Neighborhood disadvantage's non-linear moderation of sensation seeking's effect on substance use initiation suggest that perhaps past linear models of disinhibition by neighborhood interactions may have missed important quadratic effects.

In summary, the present study makes an important contribution to our understanding of the ways in which sensation seeking risk for substance use is and is not modified by individual, family, and community factors. Results showed that sensation seeking increases one's risk for substance use initiation, but not necessarily increased risk for involvement with multiple substance classes. Findings did not support a protective role of executive control, parenting consistency, or neighborhood ethnic concentration against sensation seeking risk. Neighborhood disadvantage emerged as the only factor which modified sensation seeking's risk for substance use initiation, indicating that sensation seeking risk for substance use increased as neighborhood disadvantage decreased below average levels, and that perhaps those youth at the highest levels of disadvantage also see increased sensation seeking effects on substance use. These results highlight the importance of focusing on relatively more advantaged areas as potentially risky environments for the externalizing pathway to substance use.

These results have implications for the prevention of adolescent substance use. Many alcohol and drug prevention programs are geared towards youth in impoverished communities that are often perceived as at highest risk. The results presented here highlight that youth from more advantaged neighborhoods are also at risk, specifically for sensation seeking-related substance use. Findings can be used to inform prevention

efforts to educate parents from more advantaged communities about their children's' risk (Luthar & Latendresse, 2005a) and also to inform the effective family-focused interventions which exist to improve parent-child relationships, closeness, and communication among families of all socioeconomic backgrounds (Foxcroft & Tsertsvadze, 2011).

The present findings could be used to inform other types of innovative interventions which have exhibited preventive effects on substance use of late. For instance, a teacher-delivered selective intervention which targets sensation seeking youth has shown promise in reducing alcohol use and misuse (Conrod et al., 2013). Perhaps this sort of intervention would be particularly useful in schools that serve socioeconomically advantaged communities. On a broader level, universal televised messages have demonstrated effects on marijuana use reduction among sensation seeking youth (Palmgreen, Lorch, Stephenson, Hoyle, & Donohew, 2007). The results here suggest that perhaps these media campaigns could be targeted at television markets with higher proportions of affluent viewers in hopes of reducing substance use among this high risk group. Finally, these results have to potential to inform those promising interventions which approach substance use from the community level. For instance, the efficacious Communities that Care model (Hawkins et al., 2009) has recently been extended to an affluent Washington community, and unpublished preliminary results suggest promising effects on changing social norms around adolescent drinking ("Mercer island ctc," 2011). Results from the present study highlight that such interventions might focus on sensation seeking traits as a risk factor for youth within more advantaged communities.

Although the research focus on the importance of neighborhood environments is increasing, there is still a paucity of research, particularly longitudinal studies, on the complex interplay of individual and contextual risks in adolescent development of substance use. More quality research is needed to further increase our understanding of these processes and inform future research, intervention, and policy.

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