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Intergenerational Continuity and Discontinuity in Substance Use: The Role of Concurrent Parental Marijuana Use

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Abstract

Purpose: This study examines whether parental marijuana use that occurs during the life of a child impacts patterns of continuity and discontinuity in adolescent substance use among father-child dyads.

Methods: The study uses data from 263 father-child-mother triads involved in the Rochester Youth Development Study (RYDS) and the Rochester Intergenerational Study (RIGS). We use a dual trajectory model is used to examine the research questions.

Results: Results suggest that both paternal and maternal marijuana use during the child's life increase the probability that a child will follow a moderate or high substance use trajectory during adolescence, beyond the risk incurred from paternal adolescent history of substance use. Some nuances related to the timing of concurrent parental marijuana use emerge across parent sex.

Conclusion: Concurrent parental marijuana use predicts child's substance use beyond a parent's prior substance use history. The results highlight the important role of both caregivers in the explanation of patterns of discontinuity across generations, as well as the relevance of considering when the use occurred.

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Keywords

Intergenerational substance use; Intergenerational discontinuity; Group-based trajectory models; Marijuana use; Adolescent substance use

There is a well-documented association between substance use in parents and children across adjacent generations (e.g., Cranford, Zucker, Jester, Puttler, & Fitzgerald, 2011; Kerr, Capaldi, Pears, & Owen, 2012; Knight, Menard, & Simmons, 2014; Thornberry, Krohn, & Freeman-Gallant, 2006). While these associations were originally studied using cross-sectional or retrospective data (e.g., Brook, Brook, Gordon, Whiteman, & Cohen, 1990; Fergusson, Boden, & Horwood, 2008), the genesis of prospective, longitudinal studies that span multiple generations has allowed for an examination of intergenerational (IG) continuity in substance use between parents and offspring during the same developmental period. Evidence from these IG studies suggests that there is a modest yet important association between parent and child substance use during adolescence (Bailey et al., 2016; Henry & Augustyn, 2017; Kerr, Tiberio, & Capaldi, 2015; Knight et al., 2014).

While intergenerational continuity in substance use is apparent, there is also a substantial level of IG *discontinuity*. Unfortunately, discontinuity has received scant attention and requires further investigation (Rutter, 1998; Thornberry, 2016). Recent work documenting discontinuity has noted that not all forms of discontinuity are similar in that they are merely departures from continuous behavior from parent to child (Loughran, Larroulet & Thornberry, 2018). Specifically, discontinuity can take the form of resilience, whereby children engage in lower levels of substance use compared to their parents. Alternatively, it can take the form of escalation in which the offspring uses substances to a greater degree compared to a parent. While various theoretical frameworks suggest that resilience arises from the presence of protective factors in a child's life and escalation is a result of additional risk factors in a child's life (Catalano & Hawkins, 1996; Patterson, DeBaryshe, & Ramsey 2017; Thornberry & Krohn, 2018), limited empirical work examines the risk/protective factors that explain each type of discontinuity in adolescent substance use across generations. As Serbin and Karp (2004, p. 335) argued, understanding "why children do, or do not, grow up to resemble their parents … may help us understand the etiology of complex patterns of behavior…".

Beyond IG linkages in parent and child behavior in similar developmental periods (i.e., parent's adolescence and child's adolescence), there is also substantial evidence to suggest that parent substance use increases the likelihood of substance use during adolescence among offspring when the parent's substance use occurs during the life of the child (Chassin, Curran, Hussong, & Colder, 1996; Capaldi, Tiberio, Kerr, & Pears, 2016). Johnson and Leff (1999), for example, implicated parental substance use as a key risk factor in a host of maladaptive behaviors in offspring, including substance use. One implication is that parent substance use during the life of the child may account for patterns of continuity and discontinuity over similar developmental periods (i.e., adolescence) observed across generations. For example, if a parent who used substances during their own adolescence

desists from illegal substance use once they become a parent, then the likelihood of intergenerational continuity in substance abuse may be mitigated.

Using multigenerational, prospective data from the Rochester Youth Development Study (RYDS) and the Rochester Intergenerational Study (RIGS), we describe intergenerational continuity and discontinuity in substance use between fathers and their firstborn child during adolescence. Given the joint prevalence of both alcohol and marijuana use during adolescence, our measure of substance use is a combined measure of both substances. To account for heterogeneity in substance use of both generations, we use dual group-based trajectory models (Nagin & Tremblay, 2001), which allow for a rich description of continuity and discontinuity across generations (Loughran et al., 2018). Then, we examine whether parental marijuana use that occurs during the life of the child impacts patterns of continuity and discontinuity across generations. We focus on parental marijuana use, which was illegal during data collection for most participants and had a higher prevalence of use compared to other illicit drugs. Notably, we consider independent measures of both father and mother marijuana use, recognizing that each parent may play a different role in explaining the patterns of intergenerational continuity and discontinuity in adolescent substance use.

Parental and Child Substance Use

According to the life-course paradigm, individuals are embedded in social relationships where lives are inevitably interdependent (Elder, 1998). Such *linked lives* provide both opportunities and misfortunes that become intergenerational when considering parents and children across adjacent generations (Elder, 2001). Although there is a considerable amount of research categorized under the umbrella term “intergenerational,” there is a growing consensus regarding the necessary conditions for sufficiency in IG studies, including the need to observe a parent and their offspring during the same developmental stage (Cairns, Cairns, Xie, Leung, & Hearne, 1998; Serbin & Karp, 2004; Thornberry, 2009; Thornberry, 2016). The recent proliferation of prospective, multigenerational longitudinal studies allows for this sufficiency. Notably, such studies provide researchers a better understanding of the influence that a parent’s behavior has on offspring development, as well as the level of continuity in behavior across generations.

Importantly, intergenerational research distinguishes between the *concurrent* impact of the parent’s behavior on the child’s behavior, and the *intergenerational* effect, which reflects the relationship between the parent’s developmental history of a specific behavior and their child’s behavior during the *same* developmental period (Thornberry, 2009). While both implicate a relationship between parent and child behaviors, establishing a concurrent relationship does not fully illuminate the magnitude of the IG connection (Thornberry, 2009), and vice-versa. This is particularly apparent in the case of the development of behaviors that have a strong age component, such as substance use.

The distinction between concurrent and IG continuity is especially relevant as the mechanisms underscoring continuity may be quite different for each (Kerr et al., 2012; Nadel & Thornberry, 2017; Thornberry et al., 2006). Concurrent use by a parent, for

example, may increase the likelihood of offspring substance use through direct exposure, or the dissemination of supportive norms. In contrast, continuity between parent substance use as an adolescent and offspring substance use during adolescence—IG continuity—may be explained by genetic risk as well as disrupted life-course trajectories among parents. Moreover, concurrent parental substance use may itself explain patterns of IG continuity, in which persistence in use by the parent could increase the chance of use by their offspring. Therefore, a joint consideration of historical parental use and concurrent parental use are needed to better understand patterns of continuity in substance use among parents and children.

Intergenerational Continuity in Substance Use

While there is a breadth of research demonstrating that parental substance use (alcohol, marijuana, and/or other illicit drug use) measured either concurrently or recently in time is a risk factor for offspring substance use (Bailey et al., 2016; Kerr et al., 2012; Richardson et al., 2016),[1] only a small number of studies have investigated similarities in substance use across adjacent generations following an intergenerational approach. For instance, Thornberry and colleagues (2006) examined the relationship between parent and child substance use—which included alcohol and marijuana use—during adolescence. The authors found a substantial level of intergenerational continuity among females and their offspring, but not among males and their offspring. However, the offspring in their sample were very young at the time—only 9% were 14 or older; therefore, this study only examined continuity in substance use at the onset of adolescence among parent-child dyads where the parent had the child at a relatively young age (<23).

Additional research also examined continuity in substance use during adolescence, and the results are largely mixed. Kerr and colleagues studied IG continuity in substance use (Kerr et al., 2012; Kerr et al., 2015) among father-child dyads in the Oregon Youth Study. Maternal use during adolescence was collected retrospectively. For offspring alcohol use, paternal adolescent alcohol use and paternal adult alcohol use predicted experimentation with alcohol by the child, although the effect of the former was totally mediated by the later (Kerr et al., 2012). For offspring marijuana use, parental marijuana use (including both father and mother use) during adolescence increased the risk for offspring onset of marijuana use, but only indirectly through contextual risk factors (i.e., deviant peers) (Kerr et al., 2015). Additionally, Knight and colleagues (2014) found support for continuity in substance use (alcohol, marijuana and other illicit drug use) when parental substance use was assessed in emerging adulthood. However, no intergenerational continuity in substance use emerged when parental use was limited to adolescence (ages 12-17).

Bailey and colleagues (2016) examined the effect of parental marijuana use on offspring use of different illicit substances and concluded that historical parent use did not predict offspring illicit substance use; rather it was only current marijuana use among parents that

[1]Reviews of this research conclude that exposure to parental substance use (i.e., concurrent use) increases the risk for use among offspring, regardless of survey design (i.e., cross-sectional, retrospective reports versus prospective, longitudinal data; e.g., Rossow et al., 2016; Ryan et al., 2010). Notably, this similarity in behavior is not limited to the use of the same substance; rather, any one type of substance use by a parent increases the risk for alcohol, marijuana and other drug use among offspring often as a result of co-morbidity between substance used by parents (Hawkins, Catalano & Miller, 1992; Li et al., 2002).

was related to offspring marijuana and alcohol use. It is not surprising then that Henry and Augustyn (2017) found that paternal marijuana use during adolescence was related to a child's early onset of marijuana use, but this relationship was entirely indirect through a paternal substance use disorder.

Finally, Nadel and Thornberry (2017) reported a more complex picture of intergenerational continuity, where parent sex and timing of use were interwoven to explain patterns of continuity. While substance use (a combined measure of alcohol and marijuana use) by females and males were both risk factors for offspring substance use, maternal substance use was only significantly related to offspring use when her use occurred during the child's early adolescence (i.e., concurrent use). In contrast, paternal substance use increased the risk of offspring substance use only when his use occurred during his own adolescence.

Overall, the findings suggest that parental substance use during adolescence increases the risk for use among offspring, in some cases indirectly through contextual risk factors or later substance use. While most studies have analyzed IG continuity among specific substances, the research also recognizes the co-morbidity in the types of substances used, and the fact that the risk imposed by any one substance is not limited to use of the same substance among the next generation (Bailey et al., 2016; Capaldi et al., 2016). The impact extends to other substances as well, suggesting some level of heterotypic continuity.

Limitations to the Study of Intergenerational Continuity in Substance Use

Despite the contributions of prior research, there are several limitations worthy of note. While initial work concentrated primarily on offspring substance use at early ages, given the natural restrictions on data availability that characterize IG study designs (Thornberry, 2016), more recent studies have been less limited by this age/data limitation. Still, there are few studies that consider differences in the development or progression of behavior in adolescence among offspring. Instead, outcomes are mostly measured at a singular age or ages (e.g., 14 or average from 14-16). However, the existing research show that an early and long-term involvement in substance use is associated with a plethora of negative outcomes, such as dropping out from school (Cobb-Clark et al., 2015), early pregnancy (Odgers et al., 2008), depression (Brook et al., 1998), and later substance use problems (McCauley et al., 2015). Therefore, being able to distinguish between, for example, experimental use and chronic use during adolescence may bring important implications for policy and prevention.

Similarly, in terms of parental substance use, most work analyzed parental substance uses as a single indicator—either based on the frequency of use at one time or across some number of years (Bailey et al., 2016; Kerr et al., 2012; Knight et al., 2014; Henry and Augustyn, 2017). In either case, the resulting coefficient represents the risk of parental behavior imposed to the child. Unfortunately, though, this singular representation of parent substance use likely obfuscates important patterns of continuity that lies behind that summary measure. Accordingly, Loughran et al. (2018) recently observed that the level of IG continuity expressly depends on how one accounts for the heterogeneity in different patterns of substance use across generations. Specifically, the authors found that what constituted 'continuity' in behavior tended to narrow when more granular definitions of substance use were considered. Relatedly, risk factors for IG continuity tended to change

depending on these various definitions, which emphasizes the need to better explain the mechanisms behind these patterns. For instance, Thornberry (2016) noted that not all forms of discontinuity are similar. The umbrella term of "discontinuity" masks two qualitatively different phenomena: *resilience*, when a child engages in lower levels of substance use compared to their parents, and *escalation*, when an offspring uses substances in a greater degree compared to their parents. Each one of these two patterns are likely associated with different correlates and mechanisms. As such, merely classifying continuity based on similar behavior (i.e., use) or discontinuity based on dissimilar behavior will necessarily obfuscate underlying risk factors for distinct positive and negative transitions. It is also quite likely that the mechanisms involved in these two distinct processes are different and need to be separately considered (Loughran et al., 2018). Overall, distinguishing between these different patterns can add to our understanding of the causes of behavior, as well identify factors that interventions should either enhance (to increase odds of resilience) or prevent (to decrease odds of escalation) (Thornberry, 2016).

In addition, as noted by Serbin and Karp (2004), many IG studies using prospective, longitudinal data only focus on the biological parent who was involved in the original data collection and ignore the fact that children have two biological parents whose histories and behavior may independently influence the child's development (Serbin & Karp, 2004). Even when some studies attempt to account for the other biological parent, information about fathers and mothers is often combined into a single parental substance use measure (e.g., Bailey et al., 2016; Kerr et al., 2015). This is not ideal given that Conger and colleagues (2012) demonstrated that characteristics of the "other" parent—the one not participating in the original study—play a key role in explaining patterns of intergenerational continuity between the focal parent and the common child. Further, given the different roles that parents play in child rearing, understanding the unique effect of each parent may provide a better understanding of the mechanisms behind the effect of parental concurrent drug use on the child's behavior. Only two known studies on IG substance use examined the effect of each biological parent's concurrent substance use on the child's use (Capaldi et al., 2016; Kerr et al., 2012), and both found support for an independent effect of maternal and paternal substance use. Still, more research is needed to better address patterns of continuity when accounting for substance use among both biological parents.

Current Study

The current study aims to provide a descriptive account of the role of concurrent parental marijuana use in explaining the patterns of continuity and discontinuity in substance use among adjacent generations. Specifically, we consider the role that concurrent marijuana use by each parent plays in the association between trajectories of paternal adolescent substance use and adolescent substance use by offspring. We first consider the following research question:

1. Does concurrent paternal marijuana use (use that occurs during the life course of the child) alter observed patterns of continuity and discontinuity between father and child adolescent substance use?

Then, recognizing the importance of both biological parents for patterns of IG continuity and discontinuity (Serbin & Karp, 2014), we incorporate maternal marijuana use during the life of the child into this IG inquiry and pose the following research question:

2. Does concurrent maternal marijuana use (use that occurs during the life course of the child) alter observed patterns of continuity and discontinuity between father and child adolescent substance use?

The life course approach underscores the relevance of the timing of different events and transitions in an individual's life. As such, events that occur during different developmental periods in the life course take on different meanings and differentially affect subsequent behavior (e.g., Thornberry & Henry, 2013). At this point, no known study has investigated comparatively the effects of concurrent parental substance use that occurs during different periods of the child's development (e.g., childhood versus adolescence).[2] However, the risk posed by concurrent parental substance use may well vary depending upon timing in relation to the life course of the child (Elder, 1998) due to the different mechanisms it may invoke to affect child behavior (e.g., transmission of favorable norms towards illicit substance use at an early age, availability of substances in the home during adolescence, or a genetic risk manifesting in any period of development). Therefore, we posit two additional research questions:

3. Does the effect of concurrent paternal marijuana use on patterns of IG continuity vary depending on when it occurs in the child's life (i.e., prior to or during adolescence)?

4. Does the effect of concurrent maternal marijuana use on patterns of IG continuity vary depending on when it occurs in the child's life?

Based on prior literature, we hypothesize that concurrent paternal and maternal marijuana use during the child's life will increase the likelihood of escalation in substance use in adolescence across generations (i.e., elevated substance use by the child). Regarding the timing of use, we refrain from any a priori hypotheses given the lack of prior scholarship with respect to when in the child's life parental marijuana use occurs.

Methods

Data

The data for this study comes from the Rochester Youth Development Study (RYDS) and its intergenerational extension, the Rochester Intergenerational Study (RIGS). The original study (RYDS) was designed to understand the development and consequences of delinquency and drug use during adolescence. RYDS began in 1988 with a community-based sample of 1,000 adolescents, representative of the 7th and 8th grade public school student population in Rochester, New York (Generation 2/G2). Youth at high-risk for antisocial behavior were overrepresented by disproportionately stratifying on gender (3:1 males to females) and high-crime areas of the city (see Thornberry et al., 2018 for details).

[2]Knight et al. (2014) included a distinction for the time of use, but it was contingent on the parent's own age, which does not necessarily correspond with a child's developmental stage.

G2s were interviewed nine times at 6-month intervals between average ages of 14 and 18, then annually between the average ages of 21 and 23, and again at the average age of 29 and 31, respectively.

RIGS began in 1999 by selecting the oldest biological child (Generation 3/G3) of G2 (average child age was 6 at Year 1of RIGS). Each subsequent year, new firstborns of G2s were added as they turned 2. Interviews were collected annually from G2s as well as the child's other primary caregiver (OCG) through child age 17; if G2 was a male 93% of OCGs were biological mothers (Thornberry, 2016). G3s completed annual interviews beginning at age 8. By project Year 20 (2018; the last year of data collection used in this analysis), there were 539 G3 children, 353 are the first-born children of G2 males.

The analytic sample includes children of G2 fathers where the OCG is the biological mother (hereafter mother). Our choice to restrict the analytic sample to G2 fathers was based on the availability of data from the OCG who was the other biological parent of G3. In RIGS, information was collected over time from the OCG, but persistently only for G2 males (i.e., when the OCG was (typically) the biological mother). Therefore, to preserve the triad of child-biological father-biological mother, we restrict the analysis to only children of G2 males for which the OCG reporting was the biological mother. Additionally, to be included in the final analytic sample, G3s must have had valid data for at least 2 of the 5 years of adolescence investigated (ages 14 to 18). These restrictions yielded N=263 G2 father-OCG mother-G3 child triads.[3] Among these triads, G3s were mostly minorities, with 58% identifying as Black non-Hispanic and 21% identifying as Hispanic. Only 12% identified as White non-Hispanic. G3s are relatively evenly split by gender (51% female). Overall, the analytical sample differs from the other families involved in RIGS in terms of greater parental substance use during adolescence, younger parental age when the child was born, and lower community arrest rates at the start of RYDS. We address the implications of these differences in the Discussion. All data collection procedures were approved by the University at Albany's Institutional Review Board.

Measures

The measures of father (G2) and child (G3) adolescent substance use are based on self-reported information from interviews that occurred between the ages of 14 and 18 for each generation. At each interview, respondents self-reported alcohol use (beer, wine, wine coolers, or liquor) and marijuana use since date of last interview (approximately 6 months (G2) or 12 months (G3)). If any use was indicated, individuals were asked how many times they used the substance since the date of last interview. Based on this information, we created a measure of *incidence of substance use* that sums the frequency of alcohol and marijuana use at each age between 14 and 18 (based on 9 interviews for G2s and 5 interviews for G3s). Due to differences in the specific illicit drugs queried in RYDS versus RIGS and the infrequency of any other illicit substance use in RYDS and RIGS, we limit our measure of substance use to alcohol and marijuana incidence only, the two primary

[3]A total of 73 children had less than two observations between ages 14 and 18, in most cases due to their younger ages. From those who had the requisite data, 13 did not have a biological mother involved in the study, and 4 did not have any information about paternal and maternal marijuana use between the ages analyzed.

substances used by the participants. The frequency of substance use was top coded at 100 due to its extreme right skew.

Our key independent variables, concurrent marijuana use during the life course of the child, are based on self-reports of the prevalence of *marijuana use* in the past year by both the father (G2) and the mother (OCG), separately, at each annual interview in RIGS. Specifically, we created three measures of marijuana use for both the father and the mother. First, we created a binary prevalence measure of *any concurrent marijuana use during G3's life* (ages 7 to 17).[4] Next, we created two additional measures for each parent which describe when in G3's life marijuana use was reported. Specifically, these two measures describe if any use was reported during *G3's childhood and early adolescence* (ages 7 to 13; i.e., before the developmental period of interest for G3's substance use), and if any use was reported during *G3's adolescence* (ages 14 to 17; i.e., concurrent adolescent substance use). Descriptive statistics are reported in Table 1.

Analytic Plan

Our analysis proceeds in several stages. First, to account for heterogeneity in substance use over ages 14 to 18, we used group-based trajectory modeling (GBTM; Nagin 1999, 2005) to identify clusters of similar individual-level trajectories of incidence of substance use for both father and child, respectively. Given the small sample, we proceeded with model selection in the interest of parsimony (Loughran and Nagin, 2006) (see Tables S1 and S2 in the Supplemental material). More specifically, in addition to the traditional model selection criteria proposed by Nagin (2005),[5] we limited the number of groups, based on posterior classification of group membership, to those with at least 30 members.[6]

Next, we employed dual group-based trajectory models (Nagin & Tremblay, 2001; Nagin & Odgers, 2010) to estimate the joint relationship between parent and child trajectories. The dual trajectory model was initially formulated to analyze the development of two distinct, but related outcomes (Brame, Mulvey and Piquero, 2001; Nagin, 2005). We applied the model to study the linkages between paternal and child behaviors. In addition to the traditional growth parameters generated by GBTM, the dual trajectory model also yields estimates of intergenerational conditional probabilities of substance use patterns, $P(\text{G3} \mid \text{G2})$ where G3 represents the child's trajectory group and G2 represents the father's trajectory group, which describe the probability that a child follows a given trajectory (pattern of substance use) given the trajectory followed by one's parent. Compared to a singular summary measure, this approach allows for a rich description of continuity and discontinuity

[4]Due to the nature of data collection (start year of 1999 and first-born average age of 6 in this year), numerous triads were missing information on parental marijuana use prior to this age. Thus, we decided not to include information of parental marijuana use before age 7. The measure was created using all information available between ages 7 and 17, but over 80% of the parents have information in most (over 70%) of the yearly measures.

[5]We evaluated the trajectory solutions using the range of parameters suggested by Nagin (2005): the odds of correct classification for each group exceeds 5; the mixture probabilities are close to the percentage of the sample hard classified to each group; and the 95% confidence intervals for the mixture probabilities are reasonably narrow. All these indicators suggest that the models adequately represent the sample (see Table S2 in the Supplemental material). We also note that in each of our trajectory groups, the mean conditional posterior probability exceeds .98, suggesting a judicious model (Roeder, Lynch, & Nagin, 1999).

[6]Although a 4-group solution has a lower BIC for father's and child's substance use, in each case two of the groups have less than 30 individuals. See Table S3 in the Supplemental material.

in patterns of substance use, including estimates for the conditional probability of escalation and resilience (Loughran et al., 2018).

We next tested whether parent marijuana use which occurs during the life of the child alters the probabilities of transitioning from each of the parent (G2) trajectories to each of the child (G3) trajectories (Nagin, 2005). We did so using an extension of the dual trajectory model that allows the conditional probabilities, $P(\text{G3} \mid \text{G2})$, to vary as a function of individual-level variables (Jones & Nagin, 2007; Nagin & Odgers, 2010). Specifically, we used the following constrained multinomial logit:

$$\pi_{k \mid j}(w_i) = \frac{e^{\gamma^0_{k \mid j} + \gamma'_k w_i}}{\sum_k e^{\gamma^0_{k \mid j} + \gamma'_k w_i}} \qquad j = 1, \ldots, J .$$

where the subscripts k and j represent child's (G3) and father's (G2) trajectory groups, respectively, $\boldsymbol{\pi}_{k|j}$ represents the transition probabilities that link father to child trajectories, and w_i represents the set of predictors for these probabilities, in our case, either paternal or maternal marijuana use during adulthood. As described by Nagin (2005), this specification assumes that the impact of the current marijuana use variable on the probability of membership in any specific G3 trajectory group does not interact with membership in G2 trajectory. In other words, using the constrained multinomial logit model, we calculated the predicted probability of transition from each G2 trajectory to each G3 trajectory by parental current marijuana use. Finally, we replicated the previous analyses using the developmentally specific measures of parental marijuana use (father and mother) to further explain the observed relationships of continuity and discontinuity in substance use during adolescence across generations. All analyses were conducted in Stata version 15 (StataCorp, 2019).

Results

Patterns of Substance Use across Generations

Figure 1-Panel A presents a three-group trajectory solution for fathers' substance use between ages 14 and 18. Approximately 63% of the fathers are classified in a low user trajectory group, which combines abstainers and those who report a very low incidence during adolescence. Usage in this group remains low throughout the age span with an average cumulative number of uses of 7 between ages 14 and 18 (an average of 1 incident per year). Approximately 25% of fathers are classified in the second group, which displays moderate use. More specifically, their pattern of use is represented by a slightly increasing rate of substance use between ages 14 and 18, with an average cumulative incidence of 85 which represents about 17 incidents per year. Finally, 11.8% of G2 fathers are classified in the high-use group, with an average cumulative incidence of 512 between ages 14 and 18, or more than 100 incidents per year.

A similar three-group solution emerges for G3s (see Figure 1-Panel B). Approximately 68% of the children are classified in a low user group, with the average cumulative incidence of substance use across the age span of 1 incident. Nearly 21% of children are classified in the

moderate user group. This group reported an average cumulative incidence of 25 between ages 14 and 18, which is approximately 5 incidents a year. Finally, 11.4% of the offspring are classified in a high-use trajectory, reporting, on average, 474 incidents of substance use during this period, or more than 90 incidents a year.

Linking Patterns of Substance Use across Generations

We next estimated a dual trajectory model of the joint relationship between parent and child trajectories of substance use to describe continuity and discontinuity in substance use during adolescence. Table 2, Panel A reports the probability that a child follows a certain trajectory given the trajectory followed by their father (i.e., $P(G3 \mid G2)$). The probability that G3 belongs to a certain group is conditional on G2's trajectory group; therefore, the probabilities in each row sum to 1 (Nagin & Odgers, 2010). As shown, the likelihood of the child being in the low use group is the greatest for each paternal trajectory group, but while the point estimates imply a slight decrease as the father's level of substance use across this similar age span increased, the differences do not reach conventional statistical significance ($p<.05$). The results also suggest that the chances of a child being in a higher use trajectory increases with increasing substance use by the father.

Table 2, Panel B, which presents the joint probability of trajectory group membership for the father-child dyad, further speaks to patterns of continuity and discontinuity. In this panel, all possible combinations are enumerated and the probabilities for all cells sum to 1. Consistent with prior work (Loughran et al., 2018), a considerable amount of discontinuity in substance use from parent to child emerges. Some 51% of the children are off-diagonal and display discontinuous behavior (on-diagonal cases represent continuity in substance use). Specifically, about 24% of father-child dyads show evidence of resilience from father to child (below-diagonal cases) which indicate that substance use among children is lower than that of fathers.[7] On the other hand, 27% of father-child dyads show evidence of escalation (above diagonal cases) which indicates a higher level of substance us among children compared to their fathers.

The Effect of Paternal Marijuana Use on IG (Dis)Continuity in Substance Use

The previous results describe the overall association between paternal substance use in adolescence and child substance use during adolescence. We now switch to examining the impact of concurrent marijuana use by the fathers. As reported in Table 1, 51% of the fathers reported use of marijuana at some point during the child's life. While those fathers in the high-use trajectory were more likely to report marijuana use (91%), there are nontrivial percentages of fathers from the other two adolescent trajectory groups who also reported

[7]As an anonymous reviewer pointed to, trajectory groups are estimated within each generation and, as such, "resilience" may be just reflecting population-level declines in substance use among recent generations, and not individual-level resilience. The results for both generations are relatively similar in terms of patterns: an abstainer/experimental group, a moderate user group and a high-level group, with two primary differences: first, the amount of use similarly differs between like groups across generations (as reported in Table 1), and second, the probability of the groups changes between the two generations. Importantly, the higher proportion of G3s in the low use group (68%) compared to G2s in a low use group (63%) is reflective of the secular change across generations, for which our analytic strategy is able to directly account, as we focus on these patterns for continuity and discontinuity. Recognizing this fact, we retain the language "resilience" to be consistent with prior IG research (e.g., Thornberry, 2016; Thornberry et al., 2018).

marijuana use during their child's life (35% and 67% of those classified in the low trajectory and moderate trajectory, respectively).

The next set of models (Table 3) report if these conditional probabilities linking trajectories of paternal substance use with trajectories of child substance use vary as a function of the father's marijuana use during the life course of the child (Nagin & Odgers, 2010). For each child trajectory group, the corresponding coefficient should be interpreted as the effect of paternal concurrent marijuana use on the log odds of a child belonging to either the moderate (first coefficient) or high-use group (second coefficient) relative to the low-use trajectory group, controlling for father's history of substance use during his adolescence. As indicated in Table 3-Panel A, controlling for the adolescent substance use trajectory of the father, paternal marijuana use at any time during the child's life increases the chance of the child belonging to both the moderate or high-use group relative to the low-use group, with a much larger and robust effect demonstrated for child's membership in the high-use group.

To illustrate the role of paternal adult marijuana use in the relationship between G2 adolescent patterns of substance use and G3 adolescent substance use, we transformed these coefficients into conditional probabilities for two prototypical situations, $P(\text{G3} \mid \text{G2, risk} = 1)$ and $P(\text{G3} \mid \text{G2, risk} = 0)$ where G3 represents the child's trajectory group, G2 represents the father's trajectory group, and risk represents paternal concurrent marijuana use. If paternal marijuana use between child ages seven and 17 alters patterns of intergenerational continuity, we would expect to observe that the probability of the child following a specific trajectory would be different among those whose fathers do not use marijuana and those whose fathers concurrently use marijuana, beyond the differences imposed by paternal trajectories of substance use during adolescence. Resilience would be demonstrated by a child whose father followed a moderate or high-use trajectory being more likely to be in a low trajectory if their father did not use marijuana during their life than if their father did use marijuana during their life. Conversely, in terms of escalation, a child whose father was in the low use trajectory will be more likely to belong to the moderate or high-use trajectory during adolescence if their father used marijuana during their life course.

Figure 2 depicts these probabilities. Providing support for resilience, for each father substance use trajectory group, the probability of a child following a low trajectory is greater if the father did not report any concurrent marijuana use than if the father did report marijuana use. For example, consider a child whose father followed a moderate trajectory as an adolescent (the middle panel). The probability that the child follows a low trajectory depends on concurrent paternal marijuana use, as this probability is .58 if the father reported concurrent use but increases to over .80 when the father did not report concurrent marijuana use. Figure 2 also demonstrates evidence of escalation among children whose fathers were in the moderate-use trajectory during adolescence. The likelihood of following a high trajectory increases from .05 if the father did not report any marijuana use during the life of the child to .24 if the father reported concurrent marijuana use. The same pattern is evident for children whose fathers were in the low-use trajectory and in the high-use trajectory

Table 3 (Panels B and C) reports the results of additional models examining the role of paternal marijuana use at specific developmental periods in the child's life (either prior to adolescence or during adolescence). These results suggest that the effect of paternal marijuana use may vary across child developmental stage. Particularly, paternal use when the child is between the ages of 7 and 13 increases the log odds of the child's membership in the moderate and high-use group (compared to the low-use group). Both coefficients, in particular the ones comparing high-use group with low-use group, are large in magnitude and statistically significant at .05. In contrast, the effect of paternal marijuana use assessed between child ages 14 and 17 on child's trajectory of use is smaller in magnitude and not statistically significant. It is also important to note that because of missing data, the dyads encompassed in each of the three models differs. We build on this issue in the sensitivity analysis presented at the end of the results section.

The Effect of Maternal Marijuana Use on IG (Dis)Continuity in Substance Use

We next consider the role of concurrent maternal marijuana use on a child's substance use, conditional on father's history of substance use during his adolescence. Table 4-Panel A reports results from the dual trajectory model, where the transitions between father trajectories and child trajectories are allowed to vary based on maternal current marijuana use when the child is between the ages of seven and 17. Controlling for paternal trajectory of substance use during his adolescence, maternal marijuana use increases the log odds that G3 will belong to the moderate use group (as compared to the low trajectory group). The effect on child's membership in the high trajectory group (as compared to the low trajectory group) is quite similar in magnitude; however, the standard error is larger in comparison.

Additional analyses indicate that maternal marijuana use, is for the most part, relevant to offspring patterns of substance use when it occurs during the child's adolescence, i.e. when it coincides with the development of the behavior (see Table 4, Panels B and C). Any maternal marijuana use during the child's adolescence increases the log-odds of a child being in the moderate or high trajectory group as compared to the low trajectory group. In contrast, the coefficients for maternal marijuana use prior to child's adolescence are smaller in magnitude and not statistically significant, suggesting that it is unrelated to child's trajectory group.

Figure 3 provides the probabilities of child trajectory group membership conditional on father trajectory group membership in the absence/presence of maternal marijuana use during the child's adolescence. The probability of a child following a low-use trajectory given a child's father followed a low-use trajectory decreases from .73 to .49 when the mother reported any marijuana use between child ages 14 and 17 (versus none). This result implies that maternal substance use is an important risk factor for escalation among children whose fathers displayed little substance use during adolescence. Furthermore, among children whose fathers were classified in the high-use trajectory group, the probability of the child belonging to the high-use trajectory group is reduced by half if an individual's mother did not report marijuana use (.08 versus .17, respectively). This suggests that the absence of maternal marijuana use is protective, increasing resilience among children at

increased risk for elevated substance use due to paternal developmental history of substance use.

Sensitivity Analysis

Missing data is particularly problematic in longitudinal and IG research, as those who do not participate in some or all waves are likely to be materially different from those who participate throughout the data collection period (Western, Braga, Hureau & Sirois, 2016). The current analysis is influenced by two unique problems related to missing data. First, when we considered age-restricted concurrent use separately, we found parents who did not provide any information in a specific period (i.e., late childhood or adolescence). This problem is particularly pronounced for parental marijuana use between child's ages 14-17, where 22 fathers and 8 mothers did not provide any information for their own use. Therefore, the sample size involved in the developmental-specific analyses varied. Second, among those with at least some information, there were 18 fathers and 18 mothers who were observed for less than 70% of the possible years (i.e., ages 7-17, ages 7-13, and ages 14-17) and reported no use in those years when observed. As a result, we are unable to confidently categorize their concurrent use.[8] To eliminate these cases and thus only use those triads for whom there are no missing data on concurrent parental marijuana use would have resulted in a further reduction of a sample size that already exhibits a limited amount of statistical power and may produce bias.

To deal with these issues and consider the consistency of the results across various assumptions, we conducted two sets of additional analysis (reported in Tables S4 and S5 in the Supplemental material). The approach taken is motivated by the method of nonparametric no-assumption bounds used in economics as an alternative to point estimates under strong assumptions (Manski, 1998).[9] First, for the fathers, we considered the case in which each of the 18 cases would have reported no use in all missing years if observed (i.e., the concurrent use risk was equal to 0 for each of these individuals). Second, we considered the cases in which each of the 18 cases would report use if observed in all missing years (i.e., the risk factor was equal to 1 for each of these individuals). We then estimated separate models under each scenario, the former representing a lower bound estimate and the latter being an upper bound estimate.[10] We conducted a similar analysis for the 18 mothers. The results for fathers are consistent, with the bounds being relatively closer when the risk factor was measured from ages seven to 17 and between ages seven and 13. In the case of mothers, these results are less consistent, particularly when the missing cases are imputed as 1, which

[8]We made an a priori decision that to count as a valid measure for concurrent use, the parent must be observed for at least eight periods during G3 ages 7 though 17 (i.e., 70% of the available measures). For fathers, there are 39 individuals who are observed for seven or fewer periods (of 11). Of these 39, 21 report marijuana use in at least one of the periods, which means we can confidently classify them as engaging in concurrent use (i.e., the concurrent use risk factor is coded as a 1). This leaves 18 fathers who both fail the restriction and report no use when observed and we cannot confidently assign a risk factor value. Similarly, there are 21 mothers who are observed seven or fewer periods between G3 ages seven and 17. Of these 21, three report use in at least one period and can be classified as engaging in concurrent marijuana use. This leaves 18 mothers who both fail the restriction and report no use when observed.

[9]Alternatively, one option to retain these cases and deal with the problems of missing data would be to impute data for the missing time points. We decided against doing this given that the limited number of missing cases coupled with risk factor being binary, which might yield unstable estimates in certain cells.

[10]For the time-specific models (i.e., risk factor measured between ages 7 and 13, and ages 14 and 17), parents with missing data were also recorded as 0 or 1 for the lower and upper bound estimate, respectively.

could be a consequence of increasing the percentage of females reporting a behavior that has a lower base rate. In this sense, the scenario presented in the upper bound is less likely to be realistic for mothers.

Discussion

In this paper we examined intergenerational continuity and discontinuity in substance use during adolescence. Guided by previous research documenting that parental substance use during the life of the child is a key risk factor for adolescent substance use (Chassin et al., 1996; Capaldi et al., 2016), our specific aim was to understand how patterns of continuity and discontinuity in adolescent substance use manifest across adjacent generations when accounting for parental use during the life course of the child. More specifically, examining both maternal and paternal marijuana use, we assessed whether parental use during the life course of the child affects the child's substance use beyond that imposed by the father's own history of substance use during his adolescence. In doing so, we incorporated the life course principle of timing of a risk factor (Elder, 2001) and examined whether the impact of paternal and maternal marijuana use varies by when it occurs during the life of the child.

Our results first suggest that there is some level of continuity in adolescent substance use across generations, but it is driven primarily by non-use or very low use of substances by both father and child during their respective adolescence. Moreover, when allowing for heterogeneity in substance use, nontrivial levels of resilience and escalation emerged, which is consistent with prior work (Loughran et al., 2018). For instance, offspring were most likely to belong to the low use group even if the father belonged to the moderate or high use pattern of substance use during adolescence (resilience). These patterns of discontinuity were of particular empirical interest as the present analysis sought to account for resilience and escalation through marijuana use by mothers and fathers during the life course of their children.

Second, we find some evidence that parental marijuana use during the child's life is associated with an increased probability that a child will follow a moderate or high substance use trajectory compared to a pattern of use described by abstention or experimentation. This finding reinforces prior research that stresses the importance of parental substance use after a child's birth (e.g., Chassin et al., 1996). As depicted in Figures 2 and 3, the probability of the child's membership in any specific trajectory group significantly changes when the parent used marijuana during the child's life time. These results reinforce the relevance of jointly considering the historical and concurrent effects of parental behavior to fully understand the magnitude of the IG association (Thornberry, 2009). In addition, by analyzing concurrent use as one of the potential moderators of IG continuity, the results provide a step in answering one of the key questions that IG research is called to do: how we account for discontinuity and continuity in behavior across generations (Thornberry, 2016)?

A third point that we stress is congruent with previous arguments suggesting the necessity of analyzing the influence of each parent in patterns of continuity and discontinuity across generations (Conger et al., 2012; Thornberry, 2016). Although we focused on continuity

and discontinuity in substance use during adolescence among father-child dyads, we evaluated whether concurrent maternal marijuana use can account for discontinuity. Notably, concurrent maternal marijuana use during later adolescence increased the risk that the child displayed an elevated level of substance use relative to the father's trajectory, and the absence of concurrent maternal marijuana use acted as a protective factor, increasing the likelihood of the child being in the low-use use group, irrespective of the father's substance use during his adolescence. Given these results, we recommend that future research should examine whether paternal use or nonuse can also increase the potential ill effects of maternal substance use during adolescence, given that female adolescents use illicit substances at similar levels as boys (Moffitt, Caspi, Rutter, & Silva, 2001) but fathers tend to play a secondary role to mothers in child-rearing (PEW, 2015). Further, we advocate for future research focusing on the independent role that the other caregivers play in explaining patterns of discontinuity and continuity across generations. Congruent with the life course theory concept of linked lives, maternal behavior may provide new and different opportunities to break a process of IG continuity, becoming a potential turning point toward discontinuity in substance use among generations.

A fourth point that bears emphasis is related to the importance of the timing of parental marijuana use in relation to the development of the child. Our results provide somewhat cursory support for the argument that the timing of the events matter (see also Nadel & Thornberry, 2017), though our findings admittedly lack requisite statistical power to provide a more rigorous comparison of the magnitude of these effects across different ages and missing data presents a threat to our certainty of the estimates. While testing mechanisms is beyond the scope of this study, future research should attempt to identify the potential mechanisms related to maternal use and non-use as well as paternal use and non-use, which could further inform prevention and intervention efforts. For example, the differences between the relevance of the timing of paternal and maternal marijuana use may be attributable to most mothers being the primary caregiver and living with their children, which is not the case for fathers.[11] In this regard, the buffering effect of maternal non-use during adolescence also implicates numerous mechanisms that are likely to promote discontinuity, including the imitation of abstinence, negative attitudes towards illicit substance use, negative reinforcement of illicit substance use by the child, and a family climate described by higher levels of warmth between mother and child, consistent discipline, and adequate supervision (e.g., Kelly et al., 2011). On the other hand, imitation is less likely to be a mechanism for discontinuity among fathers given their use during late childhood seems to be more important to patterns of continuity and discontinuity.

Limitations

Although the findings derived from this analysis are informative, there are several limitations worth noting. Though our data represent prospective, longitudinal data spanning multiple generations, which are necessary conditions for answering the types of research questions we pose, we are nonetheless very limited in terms statistical power, which among other things, prevents us from considering more controls in our analysis. For example, we

[11]For example, in the case of our data, 20% of the fathers had limited contact with their G3 child during their lives.

could not adjust for potentially relevant variables such as G3 sex, race/ethnicity of the family, the level of contact between father and child (see footnote 11), attitudes toward substance use by each parent, or father's age when G3 was born. As such, we see these results as informative but preliminary in nature, and we hope future research can build on them to further explore these factors and mechanisms.

Second, we used a binary measure of parental marijuana use during the life course of the child that clearly masks important variability in the level of use by a parent and, therefore, in the level of risk conferred to a child. This decision was driven by the small sample size involved in this study in addition with the categorical nature of the variables of interest produced by our analytic technique (the dual trajectory model). We considered use of other measures of concurrent marijuana use that would give a more nuanced, and likely more meaningful, look at the effects of parental concurrent marijuana use, including regular use or heavy use. However, when the table of transition probabilities that link the father trajectories to child trajectories becomes conditional on parent concurrent use measures that are relatively rare, information in the cells that were already sparse (e.g., high use by father and child during adolescence) becomes even sparser and estimation of the models becomes untenable. Therefore, while the use of a dual trajectory model to link father and child use of substances during their respective adolescence provides certain benefits in classifying continuity, escalation, and resilience – when used to model a small-sample dataset, only relatively simple models can be built upon it.

We also note that, among illegal substances, we only considered parental marijuana use. We rightfully acknowledge that other illicit substance use may be equally or perhaps even more important in the study of continuity and discontinuity of substance use across generations. However, the level of other illegal drug use in the sample is extremely small, which prevents a more formal investigation of their unique contribution in the current analysis.[12] The role of legal substance use in IG continuity is also of interest, particularly when it implies problematic use (e.g., binge drinking). Future research should extend the current analyses to other substances.

We were unable to test the effect of maternal developmental history of substance use as maternal participation in RIGS began after the child's birth. Therefore, we lacked the analog prospective data on adolescence for the mothers. Related, we recognize that the effect of maternal use may be also reflecting the effect of use by two parents. If this is the case, the results would overestimate the role that maternal substance use plays in IG discontinuity. We hope future research will consider the impact that having two parents who use drugs has on a child's own use.

Finally, our sample restrictions used to preserve the father-mother-child triad and to guarantee enough information resulted in a necessary selected subsample (i.e., only G2 males who become fathers, children who had aged into adolescence by the last observation collected, and those families who had provided data during each selected period of time),

[12]The analyses were also estimated with an overall measure of illegal substance use. However, the prevalence of illegal substances other than marijuana was extremely low (none of the mothers and only 2% of the fathers who did not report marijuana reported other illicit drug use throughout the child's life), and, therefore, the results were largely driven by marijuana use.

which directly speaks to the challenge of IG studies in terms of generalizability, sample size, and uneven age distributions of G3s (Thornberry, 2016). These problems are endemic to any type of study design charged with studying these key issues of IG risk and prevention, and we hope our study serves as an exemplar to catalog many of the difficulties faced in these endeavors.

Conclusions

Despite these limitations, this study contributes to the small but growing IG literature that point to the parental use of substances as an important risk factor for the child's own use of substances. By analyzing the joint effect of historical substance use and concurrent marijuana use on child's behavior as well as the independent effect of maternal and paternal concurrent use, this study begins to shed light on potential sources for patterns of discontinuity in substance use across generation. To be clear, this study was one step in an attempt to illuminate potential factors that promote resilience and escalation in substance use across generations by simultaneously considering historical and current use of substances by parents. Future research should build upon our findings, using it as a guide to further justify the focus on discontinuous behavior. In doing so, research will better be able to inform prevention and intervention programming that seek to improve the health and well-being of the next generation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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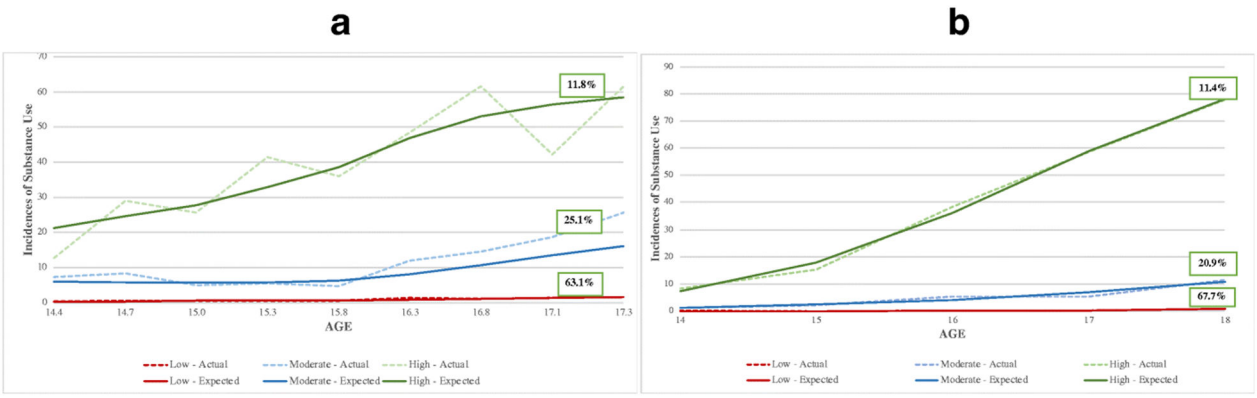

Figure 1.

Trajectories of substance use for father during his adolescence and child during their adolescence

PANEL A – Fathers' Substance Use

PANEL B –Children's Substance Use

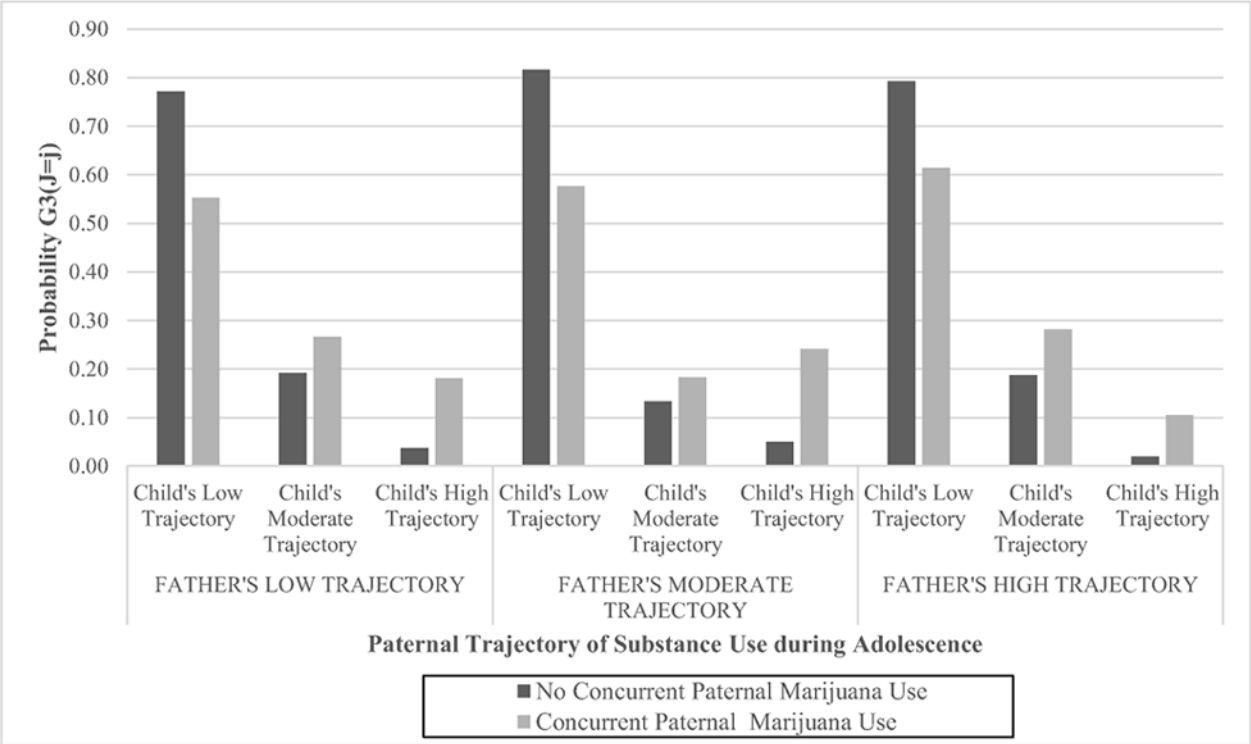

Figure 2.

Probability of child's membership in a trajectory group by father's trajectory group and paternal marijuana use during child's life (ages 7-17).

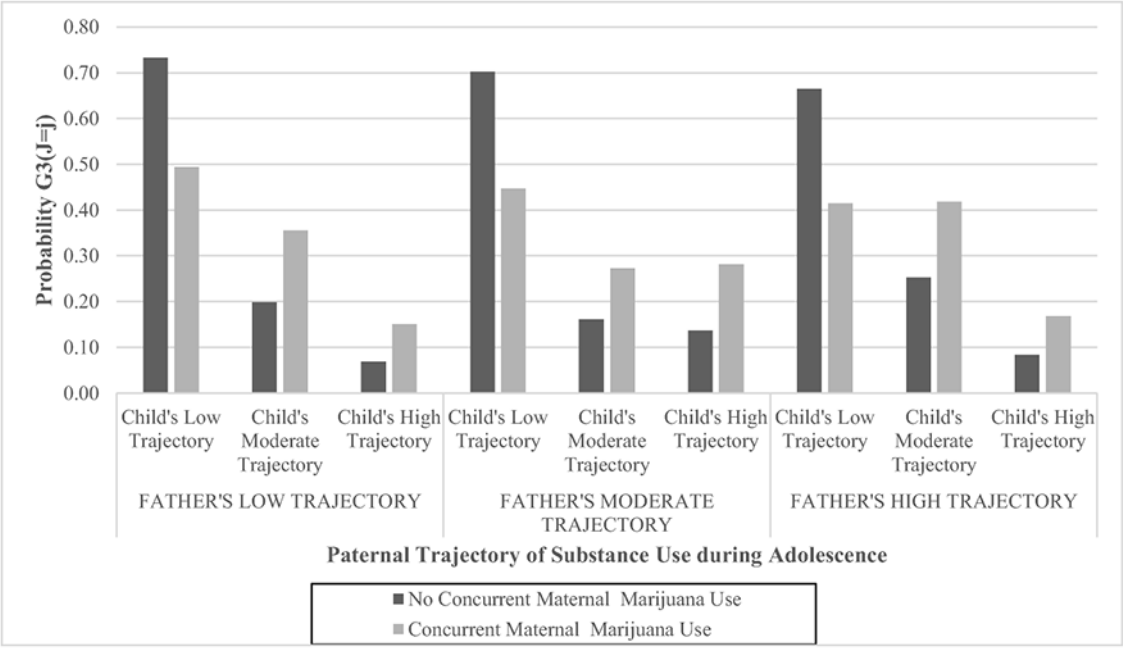

Figure 3.

Probability of child's membership in a trajectory group by father's trajectory group and maternal marijuana use during child's adolescence (ages 14 to 17).

Table 1.

Descriptive Statistics

	N	Mean	SD	Min	Max
Father's prevalence of substance use, ages 14-18	263	0.78		0	1
Father's incidents of substance use, ages 14-18[a]	263	86.0	203.1	0	2017
Child's prevalence of substance use, ages 14-18	263	0.52		0	1
Child's incidents of substance use, ages 14-18[a]	263	60.0	184.3	0	1330
Concurrent Paternal Marijuana Use					
Any use, child ages 7-17	263	0.51		0	1
Any use, child ages 7-13	262	0.48		0	1
Any use, child ages 14-17	241	0.37		0	1
Concurrent Maternal Marijuana Use					
Any use, child ages 7-17	263	0.24		0	1
Any use, child ages 7-13	260	0.21		0	1
Any use, child ages 14-17	255	0.15		0	1

[a]Summary incidence measures are reported for original (i.e., non-top-coded) measures.

Note: Father is G2 and child is G3, SD (standard deviation) is not provided for binary variables.

Table 2.

Relationship between father's and child's trajectory groups of adolescent substance use **(n=263)**

Panel A. Probability of child's substance use group conditional on father's adolescent substance use group

	CHILD'S TRAJECTORY		
FATHER'S TRAJECTORY	**Low**	**Moderate**	**High**
Low	0.69	0.22	0.09
Moderate	0.65	0.17	0.18
High	0.63	0.27	0.10

Panel B. Joint probability of father's and child's trajectory of adolescent substance use

	CHILD'S TRAJECTORY		
FATHER'S TRAJECTORY	**Low**	**Moderate**	**High**
Low	0.44	0.16	0.08
Moderate	0.14	0.04	0.03
High	0.06	0.05	0.01

Table 3.

Effect of concurrent paternal marijuana use on the conditional log-odds of child's trajectory group (Low is comparison group)

A. Paternal marijuana use during child's life (ages 7-17, n=263)		
Variable	**Coefficient (SE)**	**p-value**
Child's Moderate Group		
Paternal Marijuana Use	0.662 (0.343)	0.054
Child's High Group		
Paternal Marijuana Use	1.912 (0.536)	0.000
B. Paternal marijuana use during child's childhood and early adolescence (ages 7-13, n=262)		
Child's Moderate Group		
Paternal Marijuana Use	0.725 (0.354)	0.041
Child's High Group		
Paternal Marijuana Use	2.158 (0.543)	0.000
C. Paternal marijuana use during child's adolescence (ages 14-17, n=241)		
Child's Moderate Group		
Paternal Marijuana Use	0.558 (0.347)	0.108
Child's High Group		
Paternal Marijuana Use	−0.273 (0.478)	0.568

Note. Coefficient is the change in log odds.

Table 4.

Effect of concurrent maternal marijuana use on the conditional log-odds of child's trajectory groun (Low is comparison group)

A. Maternal marijuana use during child's life (ages 7-17, n=263)		
Variable	**Coefficient (SE)**	**p-value**
Child's Moderate Group		
Maternal Marijuana Use	0.714 (0.350)	0.042
Child's High Group		
Maternal Marijuana Use	0.782 (0.438)	0.074
B. Maternal marijuana use during child's childhood and early adolescence (ages 7-13, n=260)		
Child's High Group		
Maternal Marijuana Use	0.481 (0.373)	0.197
Child's High Group		
Maternal Marijuana Use	0.663 (0.450)	0.140
C. Maternal marijuana use during child's adolescence (ages 14-17, n=255)		
Child's High Group		
Maternal Marijuana Use	0.978 (0.408)	0.017
Child's High Group		
Maternal Marijuana Use	1.172 (0.514)	0.023

Note. Coefficient is the change in log odds.