

ABSTRACT

Title of Document: **ASSESSING TEEN RISK BEHAVIOR AND
LATER DRUG USE**

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The mechanisms of drug use and addiction influence drug policy-making and research; understanding these mechanisms is paramount to improving efficiency in drug-related research. The gateway drug hypothesis describes a progression of drug use from licit to illicit drugs. Our objective was to examine the likelihood of the gateway drug hypothesis versus a general risk taking personality that could manifest in drug use. Using data from the Youth Risk Behavior Surveillance System (YRBSS), we examined age of first marijuana use, first cigarette use, first alcohol use, first sexual intercourse, number of times in a physical fight, and how these variables related to the likelihood a person tried cocaine. Our findings lend support to the theory that people, specifically teens, demonstrate a propensity towards risk-taking rather than drug specific behaviors. A longitudinal study would aid in clarification of the results.

ASSESSING TEEN RISK BEHAVIOR AND LATER DRUG USE

By

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Team Risky Business

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Chapter 1: Introduction

It is not uncommon for youths to be told that use of cigarettes, alcohol, or marijuana will lead them down a path of destruction that ends in addiction to heavy drugs such as cocaine and heroin. In 1965 the Federal Bureau of Narcotics publicized the statement that marijuana use is involved in a path to drug abuse and dependence. The gateway hypothesis describes this path, in which early drug use leads to a progression over time in the category of drug severity. Research has shown that adolescent use of hard drugs, like cocaine or heroin, is unlikely unless marijuana use occurs first; marijuana use is also unlikely unless preceded by alcohol or tobacco use (Kane & Yacoubian, 1999). President Bush requested \$14.1 billion from Congress for the 2009 fiscal year for the National Drug Control Strategy, comprised of three main objectives: preventing the start of drug use, providing treatment for users, and obstructing the drug market (Office of National Drug Control Policy, 2009). Society dedicates a large amount of resources to drug use intervention and prevention, especially at early ages; thus, it is necessary to gain a deeper understanding of the gateway theory and how surrounding factors play a role in adolescents' progression to drug use and abuse. Moreover, increased knowledge on drug progression will allow for more efficient spending on drug prevention research, as programs can be developed with the mechanism of progression in mind. Finally, knowledge on the mechanism of drug progression will aid in the development of more effective treatment programs for those already addicted.

As many drug users typically follow this pathway of drug progression, starting

with licit drugs such as alcohol and nicotine and ending with illicit drugs like cocaine, the gateway hypothesis has gained public credence. However, a distinct weakness of the gateway hypothesis is that it does not offer any explanation or evidence for a causal linkage between lower and higher classes of drug use. Several common explanations have arisen for the drug usage pattern described by the gateway hypothesis. The first is that those that use alcohol, nicotine, or marijuana have inherent characteristics that facilitate later drug use. These characteristics, whether genetically-based or acquired, promote overall risk-taking or deviant behavior, which in this case refers to drug use. It is also possible that the shared market for marijuana and more potent illicit drugs facilitates the availability of hard drugs to lower drug users. In addition, lower drug use could induce pharmacological changes within the user that lead to increased risk for later hard drug use. Support for each of these mechanisms exists, but the factors influencing the gateway progression of drug use remain uncertain despite a multitude of studies that have demonstrated such a pathway (Kandel, 1975; Donovan & Jessor, 1983; Kandel et al., 1992; Kandel & Yamaguchi, 1993; Tanda et al., 1997; Grant, 1998; Lewinsohn et al., 1999; Kane & Yacoubian, 1999; Lai et al., 2000; Lamarque et al., 2001; Cadoni et al., 2001; Wagner & Anthony, 2002; Richter et al., 2002; Wetzels et al., 2003; Lynskey et al., 2003; Fergusson et al., 2006).

This study proposes an analysis of several possible factors that could influence subsequent hard drug use. Analyses were performed on the Centers for Disease Control (CDC) public access data set from the Youth Risk Behavior Surveillance System (YRBSS). The YRBSS is a national survey administered

biennially beginning in 1991 to U.S. high school students. Risky behavior is addressed using questions concerning physical inactivity/obesity, dietary habits, sexual activity, drug and alcohol use, and violence. This study focuses on items pertaining to early risk behaviors and substance abuse and possible relations with later drug usage. In short, the study attempts to assess the validity of the gateway hypothesis using YRBSS data.

The study was limited by the survey design and thus the inability to draw a causal relationship between the risk factors examined and cocaine use. It is important for future research to consider behavioral genetics, other environmental risk factors, and possible diagnostic and intervention tactics to reduce hard drug use.

Chapter 2: Literature Review

2A - The Gateway Hypothesis and Drug Progression

The progression of drug use detailed by the gateway hypothesis is well-documented, with many studies confirming its occurrence. In this progression, drug use begins with licit drugs such as alcohol and/or tobacco, and transitions to illicit drugs in increasing degrees of drug potency. Marijuana use gives way to “harder” drugs such as prescription psychoactive drugs, methamphetamines, cocaine, and heroin. The following studies lend support to this stepwise path of drug use detailed by the gateway hypothesis.

Kandel (1975) discussed the progression of drug development as occurring in stages. According to longitudinal studies of New York high school students, drug involvement begins with legal drugs, especially alcohol and tobacco. Three self-administered questionnaires were distributed at intervals of at least five months. The surveys asked students if they had ever used one or more of 14 substances, as well as if they had used them in the past month. Kandel observed a trend from nonuse to legal drugs to marijuana and so on up the Guttman scale of drug ranking which was used for the experiment [see Guttman, 1949]. The sequence holds for regression of drug use; users demonstrated a stepwise reduction in drug use. The data was not statistically significant; percentages were used for the purpose of discussion. Kandel noted that continuing progression is not guaranteed; many users stop at a given stage and do not progress further. Furthermore, Kandel acknowledged the significance of culturally determined factors for each stage of drug use and behavior, e.g.

contemporary social attitudes toward particular drugs.

Donovan and Jessor (1983) analyzed data for overall drug use from the 1974 and 1978 National Study of Adolescent Drinking. They found that drug involvement consisted of distinct levels of use: nonuse, non-problem use of alcohol, marijuana use, problem drinking, pill use, and hard drug use. Psychosocial variables related to problem behavior were assessed in the study questionnaires with questions concerning personality, perceived environment, and behavior. They found that illegal substance use (e.g. alcohol in underage drinkers) is associated with later marijuana and drug use, and that excessive alcohol use is more strongly associated with later, other drug use than is marijuana use. Donovan and Jessor (1983) acknowledged that their findings on levels of drug involvement do not necessarily translate to distinct stages in a sequence of drug involvement. Due to their use of cross-sectional data, their findings were limited to levels of use rather than the sequence itself. The study was limited by lack of longitudinal data and a sample consisting only of adolescents who were attending school.

Kandel et al.(1992) examined a longitudinal cohort, followed from ages 15 to 35, for sequential stages of drug involvement. They found that the four stages of drug involvement are alcohol and/or cigarettes, marijuana, prescription psychoactive drugs, and other illicit drugs. For males, the model of drug use reveals that alcohol precedes marijuana, alcohol and marijuana precede illicit drug use, and alcohol and marijuana/cigarettes precedes prescription psychoactive drug use. For females, the model of drug use is similar, except that either alcohol or cigarette use precedes marijuana use. They also found that early onset age of use of lower drug classes was

associated with later use of illicit drugs. Furthermore, frequency of drug use was related to progression in drug classes. Kandel et al. (1992) acknowledged that participation in a particular drug class does not necessarily lead to use of the next drug class. In addition, they reported that use of a drug in any class may be explained as an opportunistic response to environmental conditions in those subjects who may be characteristically vulnerable to deviance and/or drug use.

Kandel and Yamaguchi (1993) reexamined patterns of adolescent drug involvement after the rise in popularity of crack during the 1980's. Self-reported questionnaires of New York high school students were used to determine use of any of a number of legal and illegal substances. Age of first use of alcohol, cigarettes, marijuana, cocaine, and crack was elicited. From these five main classes of drugs used, several models of progression were identified. Scale models of each were tested for fit to the data using the Bayesian Information Criterion [see Raftery, 1986]. For males, it was found that alcohol precedes marijuana, marijuana and cigarettes precede cocaine and crack, and cocaine precedes crack. For females, alcohol and cigarettes precede marijuana, marijuana precedes cocaine and crack, and cocaine precedes crack. The results were consistent with Kandel et al., 1992; Kandel & Yamaguchi (1993) again acknowledged the need for more research concerning the cultural, psychological, biological, and social factors underlying progression.

Grant (1998) examined the relationship between the age of onset of smoking and alcohol use, abuse, and dependence as defined by *The Diagnostic and Statistical Manual of Mental Disorders, 4th Edition* (DSM-IV) (American Psychiatric Association, 1994). Different smoking groups were measured for prevalence of

alcohol use using linear logistic regression to assess the relationship between cigarette and alcohol use. Early onset smoking was found to be more significantly associated with increased alcohol consumption and more severe alcohol disorders than in late onset smokers and nonsmokers. Early onset smoking was also found to be associated with more frequent and prolonged lifetime smoking. Finally, early onset smoking was found to be a significant predictor of lifetime alcohol use, and the development of alcohol abuse and dependence. Grant acknowledged the need for research on the underlying mechanisms of the association between tobacco and alcohol use.

Lewinsohn et al. (1999) assessed the impact of adolescent students' tobacco use on future drug use. Subjects (ages 14 to 18) were surveyed in high school (T1), one year later (T2), and again at age 24 (T3). Subjects were also assessed for psychiatric disorders using DSM-III-R criteria at each interval; DSM-IV criteria were included in the T3 interview. It was found that smoking group status was related to parental education levels, with daily smokers being less likely to have at least one parent with a college degree. Age of onset of cigarette use was significantly associated with future alcohol and hard drug disorders; although it was in the predictive direction for marijuana use disorder, it was not significant. Status as a former smoker did not reduce the risk of later disorders, but a maintained cessation of smoking for at least 12 months did demonstrate lower rates of future alcohol disorders than more recent quitters. Furthermore, former smokers who had maintained cessation of smoking were no more likely than non-smokers to develop alcohol and/or substance use disorders by T3. Daily smokers were significantly more likely to develop marijuana and hard drug use disorders than infrequent smokers,

demonstrating a dose-dependent risk; this was not true for a future alcohol disorder. Limitations of the study included a dearth of information concerning adolescent cigarette use and cessation data for irregular smokers, small cells during analyses, and the selection of the sample from only one region of the United States.

Kane and Yacoubian (1999) assessed the gateway theory for a deviant population of adult Philadelphia arrestees. Data from the National Institute of Justice's Arrestee Drug Abuse Monitoring (ADAM) program was used, along with urinalysis to validate self-reported data (National Institute of Justice, 2007). Two alternate analytical models of gateway progression were examined, and they demonstrated an inconsistent effect of age at initial alcohol use on the age of initial use of hard drugs. Marijuana was identified as the main stepping stone drug in the escalation path; age of first alcohol use was a significant predictor of age of hard drug use when mediated by age of first marijuana use. Both models had high associated prediction error. The study was also limited by the small difference between age of first alcohol use and age of first marijuana use, less clear progression from marijuana to alternate central nervous system drugs, and the grouping of age of first use of alcohol, marijuana, and cigarettes together in the principal component analysis. Overall, the data supports the gateway theory of escalation.

Lai et al. (2000) examined the 1994 National Household Survey on Drug Abuse (NHSDA) to determine the effects of cigarette use on the initiation of use of illegal drugs. Using logistic regression analysis, cigarette smokers were shown to be more likely to use cocaine, heroin, crack, and marijuana. Smokers were seven times more likely to have tried cocaine or marijuana, and fourteen to sixteen times more

likely to have tried heroin or crack. Age of onset was also of demonstrated importance; those who began smoking before the age of 18 were up to eighty times more likely to have tried illegal drugs than non-smokers. The trends hold after race and gender are controlled, although the association magnitudes decrease with age, demonstrating the predictive nature of cigarette use in young people. Lai et al. (2000) acknowledged the need for studies concerning the role of behavioral genetics, ethnography, and developmental psychology in explaining the relationships in drug progression.

Wagner and Anthony (2002) examined the 1991-1994 NHSDA to assess proposed mechanisms on the gateway hypothesis pertaining to alcohol, tobacco, marijuana, and cocaine. The dataset comprised 44,624 U.S. household residents between the ages of twelve and twenty-five. Alcohol and/or tobacco users were roughly three times more likely to have tried marijuana than non-users. After exposure to marijuana, incidence of use was significantly related to prior use of alcohol and/or tobacco; the median lag time between marijuana exposure and marijuana use was one year. Only 20% of original non-users used marijuana within five years of the initial exposure. The relationship between alcohol/tobacco and marijuana use held for fast transitions between drug categories as well. Furthermore, marijuana users who also had used alcohol and/or tobacco were 7.6 times more likely than non-users or users outside the normal gateway progression to have an opportunity to try cocaine. Furthermore, among subjects with exposure to cocaine, initiation of use was significantly related to past marijuana exposure. Limitations of the study include the lack of subgroup examinations and need for more studies on

temporal sequences.

Richter et al. (2002) conducted a population-based study to describe cigarette use patterns among illicit drug users, the prevalence of cigarette use in drug users versus nonusers, and the relation of smoking to the level and type of drug use. Data from the 1997 NHSDA was analyzed for smoking rates, levels, and cessation rates. They found that illicit drug users had an odds ratio of 3:1 for being smokers. The prevalence of cigarette use was also higher among multiple drug users compared to single drug users. Furthermore, frequent use of drugs was also associated with smoking prevalence. Illicit drug-using smokers also demonstrated a quit level for smoking that was roughly half that of drug nonusers. Finally, illicit drug users who perceived smoking to be dangerous or risky had an odds ratio of 0.23 for being smokers. Richter et al. (2002) cited the prevalence of marijuana use and its often concurrent use with tobacco as a potential contributing factor in the linkage between tobacco and hard drug use.

Wetzels et al. (2003) examined the relationship between alcohol and tobacco use in a sample of adolescents from six European countries (United Kingdom, Spain, Portugal, the Netherlands, Finland, and Denmark), considering international, gender, and age differences. Behaviors were self-reported using questionnaires distributed in schools. The percentage of adolescents who had smoked at least once in their lifetime increased from 37% to 53% between T1 and T2 (one year interval). Danish adolescents and Portuguese adolescents showed the greatest and least smoking prevalence, respectively, at both T1 and T2. The strongest correlations were found between T1 smoking and T2 smoking, and between T1 alcohol use and T2 alcohol

use. Correlations between T1 smoking and T2 alcohol use, and between T1 alcohol use and smoking were roughly 0.3 each. Controlling for T1 age, gender, and country, T1 smoking predicted T2 alcohol use and T1 alcohol use predicted T2 smoking, although the odds ratio for the second relationship was lower. In short, the two substances were found to be reciprocally linked for the most part, although causality was not proven. Furthermore, a separate analysis by country revealed that the progression of alcohol and tobacco use is not unilateral and may be a reflection of cultural values and upbringing.

Lynskey et al. (2003) conducted a twin study of drug use in a surveyed sample of Australian young adult monozygotic and dizygotic twins. The use of a discordant co-twin study aids in controlling for potential confounding effects caused by familial factors. Subjects were pooled from the Australian Twin Registry and were administered single telephone interviews based on DSM-IV criteria. Subjects were assessed for lifetime drug and alcohol use, drug abuse and dependence, family and social factors, and psychiatric disorders. For both men and women, the prevalence for early marijuana use was more strongly associated with monozygosity, indicating a possible genetic component in susceptibility to drug use. Compared to co-twins who had not used marijuana by age 17, early users demonstrated 2.1 to 5.2 greater odds of drug use and dependence of alcohol and illicit drugs. Controlling for known risk factors had a negligible effect; early, regular use of alcohol and tobacco were the factors most consistently associated with later drug use and abuse. Overall, regardless of zygosity, individuals who used marijuana prior to age 17 demonstrated a 2.3-3.9-fold increase in odds for later drug use and a 1.6-6.0-fold increase for later

alcohol and other drug dependence compared to their non-using co-twin. Lynskey et al. (2003) assumed that being raised in the same household would minimize environmental experience discordances in twin pairs; however, one cannot rule out that possibility. Other limitations included reliance on self-reported, retrospective data and the lack of information on age of progression and onset of dependence. Causality could not be established.

Fergusson et al. (2006) conducted a 25-year longitudinal health, development, and adjustment study of a birth cohort of New Zealand children. The incidence and frequency of marijuana use as well as illicit drug use was assessed from ages 14 to 25. Several potential confounding variables were controlled for, including socioeconomic status, parental education, parental drug history, childhood abuse and punishment, and aberrant neurological characteristics. They found that increasing marijuana use was significantly associated with increased illicit drug use, although this association decreased with age. Overall, the results of the study were consistent with the gateway effect, which was supported by temporal sequencing, dose-response, size of association, and resilience to statistical control. They acknowledged that the mechanism of drug progression could entail biochemical factors, individual learning, differential association, or overall youth involvement in drug culture. Furthermore, they cited social and biological maturity, and recruitment effects to explain the age-dependent decrease in the marijuana-illicit drug association. The study was limited by the complex nature of outcomes of marijuana and illicit drug use, the self-reported nature of the data, possible omission of control of other confounding variables, and overestimation of the causal linkage through use of the

fixed-effects model.

Lynskey et al. (2006) examined a twin-cohort from the Netherlands for early marijuana use and later illicit drug use. The sample was chosen to explore if the results of Lynskey et al., 2003 study would be recreated in a different environment. Marijuana use was essentially decriminalized in the Netherlands in the 1970's to separate the marijuana and illicit drug markets, thus combating the potential threat of access to illicit drugs as a result of early marijuana use. Same-sex twins discordant for early onset marijuana use were assessed for overall lifetime use of marijuana and other drugs, frequency of use, and covariates such as alcohol and tobacco use prior to age 18 and aggressive or rule-breaking behavior. Prior to adjustment for covariates, individuals who had used marijuana prior to age 18 demonstrated significantly higher odds of party drug use, hard drug use, and regular use of hard drugs and marijuana. Controlling for covariates resulted in no significant association between early marijuana use and later regular marijuana use, although the association between early marijuana use and later party/hard drug use remained. Furthermore, roughly 6% of early marijuana users reported later illicit drug use, while none of their co-twins reported such use. Lynskey et al. (2006) acknowledged the possible confounding effects of non-shared environmental aspects among twin-pairs. Also, they suggested that early onset of marijuana use may be associated with an earlier onset of hard drug use as opposed to an increased likelihood of hard drug use. Considering the legality of marijuana in the Netherlands, the results indicate that the association between early onset of marijuana use and later drug use is not solely due to factors describing the accessibility and obtainment of marijuana. However, social mechanisms surrounding

drug progression must still be considered.

Agrawal et al. (2006) utilized a twin-cohort to examine the effects of use and early use of alcohol, cigarettes, and marijuana on the risk for initiation of illicit drug use. A sample was taken from the women who participated in the baseline and 5-year follow up interviews of the Missouri Adolescent Female Twin Study (MOAFTS) [see Heath et al., 1999]. Discrete-time survival analyses were performed with twin zygosity, race, and time-varying covariates in all models. African-American women in particular were found to be less likely to use alcohol and illicit drugs. More generally, marijuana use before age 16 was associated with alcohol and cigarette use prior to 14 and 12 years of age, while early alcohol use was associated with early cigarette use. The use of illicit drugs was positively associated with alcohol use and strongly with marijuana use, but not with prior cigarette use. Agrawal et al. cited several possible explanations for this association (2006). Individuals who follow this usage pattern may have a shared vulnerability to substance use and problem behavior. Second, early entry-level drug use could have a causal relationship with later drug use based on neuro-pharmacological changes such as common receptor sensitization. Also, environmental influences associated with drug use could increase the availability of illicit drugs. The study did not consider population specificity, the influence of aforementioned environmental and genetic factors, and male subjects.

The above studies all lend credence to the gateway hypothesis and its stepwise progression of drug use. The transition from entry-level, licit drugs such as tobacco and alcohol onto marijuana and later hard drugs has been observed in a variety of cohorts, including high school students, birth cohorts, monozygotic and dizygotic

twins, and inmates. However, the majority of these studies also detailed the need for further research on psychological, biological, cultural, and social factors underlying drug use. For example, Lewinsohn et al. (1999) demonstrated familial influence on cigarette use; subjects with higher-educated parents were less likely to be daily smokers. In addition, Wetzels et al. (2003) found that cultural factors may be responsible for differences in progression of use of alcohol and cigarettes among adolescents of different European nationalities. There is a great need for further longitudinal research concerning potential drug users and an in-depth examination of any potential risk factors in their lives that may influence drug use.

2B - Pharmacological Explanations of the Gateway Hypothesis

The pharmacological explanation of the gateway hypothesis posits that progression from lower to higher classes of drugs is a result of physiological changes in the individual induced by lower drug use. In short, use of drugs such as tobacco and marijuana induce changes within the individual that increase his or her affinity for harder drug use. The following studies offer several potential pharmacological explanations for lower drug-induced sensitization to hard drugs.

Tanda et al. (1997) compared the effects of Δ^9 -tetrahydrocannabinol (Δ^9 -THC) and heroin on dopamine (DA) transmission in a rat cohort. As the Δ^9 -THC affects the mesolimbic DA system, the nucleus accumbens (NAc) was chosen as the point of interest, as the system projects from the ventral tegmental area (VTA) into the NAc. Brain microdialysis was used to monitor extracellular DA levels in the shell and core subdivisions of the NAc. Δ^9 -THC, heroin, and the synthetic cannabinoid agonist WIN55212-2 all induced significant increases in dialysate DA in the NAc

shell but not in the core. Pretreatment with the cannabinoid antagonist SR141716A prevented the effects of Δ^9 -THC and WIN55212-2. Subcutaneous injection of naloxone, an opiate antagonist, prevented the effect of both Δ^9 -THC and heroin. Furthermore, the administration of naloxonazine, a pseudo-irreversible μ_1 antagonist, prevented the effect of both Δ^9 -THC and heroin on DA in the NAc shell. The fact that SR141716A prevented DA increases indicates that Δ^9 -THC acts on specific cannabinoid receptors to increase DA selectively in the NAc shell. Both Δ^9 -THC and heroin were demonstrated to increase NAc shell DA levels, similar to morphine, cocaine, amphetamine, and nicotine. This may explain the emotional effects of Δ^9 -THC, as the NAc shell is connected to limbic areas of the brain involved in emotion. Most importantly, naloxone and naloxonazine prevented the effects of both Δ^9 -THC and heroin, thus revealing a possible homology between the two drugs. It is possible that Δ^9 -THC induces increased DA levels in the NAc shell through an endogenous opioid system involving μ_1 receptors in the VTA. Although causality was not established, the results lend credence to the association between marijuana use and frequency of use and the risk for later use of heroin.

Lamarque et al. (2001) examined the effects of Δ^9 -THC on the locomotor response to amphetamines and heroin in order to determine the existence of a cross-sensitization. The rat cohort was pared into low-responder (LR) and high-responder (HR) groups based on locomotor reactivity determined by the response to novelty in a circular corridor apparatus. Chronic treatment with Δ^9 -THC resulted in a significant group effect on body temperature in the HR group; lower doses tended to induce hyperthermia while higher doses tended to induce hypothermia. Δ^9 -THC also

initially resulted in a decrease in food intake. However, for both of these factors, a development of tolerance was observable by the end of the chronic treatment phase. 41 days after Δ^9 -THC treatment, the total locomotor response in HR rats to heroin was demonstrated to be Δ^9 -THC dose-dependent; heroin-induced total locomotor activity was greater in HR rats. Δ^9 -THC treatment also resulted in higher total locomotor response to amphetamine in HR rats according to measures taken 3 days after the treatment course. Overall, pretreatment with Δ^9 -THC was demonstrated to have a time-dependent enhancing effect on the locomotor response to heroin and amphetamine, furthering the connection between cannabinoids and brain opioid systems. The cross-sensitization effect could be due to endocannabinoid inhibitory feedback on motor activity induced by DA agonists, or via anandamide release caused by Δ^9 -THC stimulation of dopaminergic activity. Furthermore, the results were demonstrated only in HR individuals, revealing a differential sensitivity to the long-term effects of Δ^9 -THC. Thus, it is plausible that chronic use of Δ^9 -THC in humans could lead to increased susceptibility to addictive drugs, particularly in individuals predisposed to drug taking behaviors.

Cadoni et al. (2001) conducted a similar experiment to determine cross-sensitization between Δ^9 -THC and morphine. Three rat groups were treated with increasing doses Δ^9 -THC, morphine, or a placebo for a 3-day course. After a washout period, rats from each group were administered Δ^9 -THC, WIN55212-2, or morphine and the behavioral responses to a novel environment were recorded. Behavior was categorized as either non-stereotyped (downward sniffing, repetitive gnawing, and purposeless licking) or stereotyped (forward locomotion, sniffing around). Previous

exposure to Δ^9 -THC resulted in increased behavioral response to both Δ^9 -THC and morphine administration compared to control rats. This demonstrates that Δ^9 -THC induces sensitization to itself, confirming its status as a drug of abuse that can induce self-sensitization. Also, Δ^9 -THC demonstrated cross-sensitization with morphine, furthering the support for homologies between cannabinoids and opioids. Cadoni et al. cite DA release in the NAc and VTA μ_1 opioid receptor-mediated activation of an endogenous opioid system as possible mechanisms of cross-sensitization. Overall, the results provide further support for a biochemical linkage between marijuana use and risk for subsequent opiate and other illicit drug use.

Those above and other pharmacological studies have demonstrated several possible physiological explanations for the gateway pattern of progression. It was demonstrated that use of marijuana can lead to cross-sensitization for harder drugs such as opiates; there may be a shared receptor between these drugs or another type of homology between the physiological receptors for the individual drugs. However, it is important to note that these studies only provide a possible explanation for transition between drug classes; they do not provide a causal linkage between lower drug use and higher drug use. Moreover, they do not address other variables concerning drug use, especially behavioral risk factors.

2C - Alternate Explanations of Drug Progression

Although the gateway drug progression is a demonstrated phenomenon, it is not an explanation in and of itself. Moreover, it is highly unlikely that gateway progression exists without the contribution of a myriad other factors. The following studies have assessed the association between some of these surrounding factors and

drug use.

Donovan and Jessor (1978) assessed adolescent problem drinking using data provided by a 1974 national survey [see Rachal et al., 1975]. The complete two-stage, stratified sample of roughly 15,000 consisted of high school students in grades nine through twelve. The questionnaire included questions based on the three systems of explanatory variables assessed in problem-behavior theory: personality, behavior, and perceived environment. Within the personality system, problem drinkers were found to place less value on academic achievement and religion, more value on independence and the positive functions of drinking, were less intolerant of deviance, and had lower notions of achievement compared to non-problem drinkers. These findings were consistent within the behavior and perceived environment systems as well; greater involvement with marijuana use was noted in problem-drinkers within the behavior system. Furthermore, within the perceived environment system, problem drinkers noted more influence from their friends compared to their parents and incompatibility between their friends and parents compared to non-drinkers. The consistency of the findings across the three explanatory systems suggests that adolescent problem drinking is part of a general syndrome of behavioral deviance. Combined with established results on alcohol's link to later drug use, it is plausible that progression of drug use is a manifestation of general pattern of or proneness to risk-taking or delinquent behavior. The study was limited by the exclusion of students who had dropped out of school, lack of external validation data for questionnaire responses, and the assessment of only a portion of the variables involved in problem-behavior theory.

Clark et al. (1998) examined early adolescent substance use in boys of fathers with and without substance abuse disorders; diagnosed psychopathologies in the boys were also examined as potential predictive factors. Subjects whose fathers had been diagnosed with substance abuse disorders were more likely to have tried tobacco; this trend was not seen for alcohol or marijuana experimentation. Tobacco use was also predicted by diagnoses of oppositional defiant disorder and the absence of anxiety disorders in the boys. Alcohol use was predicted by preadolescent conduct disorder. Both preadolescent conduct disorder and tobacco use strongly predicted early adolescent marijuana use. Although the prediction of marijuana use by tobacco use is consistent with the gateway theory, drug use in individuals with conduct disorder could be due to a generally deviant lifestyle. Other confounding factors include the following: fathers were self-selected, raters were not blind to subjects' characteristics in the baseline assessment, and the inclusion of males only in the study.

Sutherland and Willner (1998) conducted a classroom survey of adolescents (ages 11 to 16) that focused on the extent of use of alcohol, cigarettes, and illegal drugs. The dataset was based solely on questions regarding the incidence and frequency of drug use, and was analyzed by logistic regression. Cigarettes were the most heavily used substance behind alcohol. Cigarette use was significantly higher among girls and illegal drug use was higher among boys. Exclusive use of illicit drugs was rare; the most frequently observed pattern was a combination of cigarettes and/or drugs in conjunction with alcohol. Although the data supports the gateway hypothesis, it is also consistent with an alternately espoused theory of substance use as associated with a general pattern of delinquent behavior. Though the use of

alcohol was related to the use of other substances, the level of alcohol use was also found to have an association with substance use. For example, subjects who had been drunk more than 20 times indicated 3.5 times more use of illegal drugs than those who had been drunk less than 5 times. This greater incidence could be indicative of a personality type inclined to take more risks than normal. Sutherland and Willner (1998) noted that reported usage prevalence estimates might have been inflated by the lack of quantification of “regular use” of substances in the questionnaire. Using this survey data, they could not prove or disprove the progression hypothesis on alcohol, cigarettes, and illegal drugs.

Challier et al. (2000) conducted a cross-sectional study of middle and high school students. It examined the effect of psychosomatic status, personality, health perception, family environment, and sport activity on the use of alcohol, tobacco, and illegal drugs. The study found that the incidence of alcohol use was seven times higher and illicit drug use was 10 times higher for smokers versus non-smokers. Smoking incidence was significantly related to “boring family atmosphere” and not living with both parents. Socio-economic status was not found to be related to cigarette, alcohol, or illicit drug use. Some self-reported personality traits were found to be related to substance use: subjects self-described as calm, serious, attentive, or organized demonstrated lower prevalence than those self-described as easily irritable, worried, clumsy, solitary, ambitious, aggressive, dynamic, disorganized, careless, and having many plans. For health perception, those who attributed good health to luck were 1.94 times more likely to smoke than those who attributed good health to other factors. The Total Health Test (THT) measure of psychological vulnerability

demonstrated associations with psychotropic drug, cigarette, alcohol, and illicit drug use; this relationship was stronger for girls.

Golub and Johnson (2001) examined the National Household Survey on Drug Abuse (NHSDA) to study the progression through stages of nonuse, alcohol or tobacco use, marijuana use, and hard drug use. The study found that support for the progression theory differed based on when a person was born. People born prior to World War II were unlikely to try marijuana even if they had used alcohol or tobacco. The gateway drug theory began to see support in the 1960s as the baby boomers grew up. People who were born since the mid-60s showed less likelihood of progressing to marijuana and harder drug use. In the mid 1990s, marijuana use among youth began to rise, although it is predicted that the likelihood of this leading to later cocaine use is low. The study suggests that the gateway drug theory, and support for it, is a reflection of cultural norms rather than a causal relationship between various forms of substance use. As societal morals and attitudes toward drug use change over time, the differences in socialization can result in different drug affinities. Furthermore, the findings relate to the shared market explanation of drug progression. As the popularity of and market for specific drugs changes with time, so does the relationship between usage of different drugs.

Chen et al. (2002) examined the gateway effect of cigarette use on alcohol use in different ethnic groups of California high school students. Risk levels remained relatively constant for the subjects of similar cultural backgrounds (controlling for acculturation, school performance, and monitoring by parents) among the 11 ethnic groups surveyed; the risk also did not vary with gender or grade. The groups with the

highest rates of smoking initiation were Mexican, Filipino, South and Central American, and White; those with the lowest rates were Chinese, Japanese, Korean, and Vietnamese. There was a strong association between prior cigarette use and past 30-day alcohol use. Although this did not identify a causal linkage between cigarette use and alcohol use, it was consistent with the gateway hypothesis. The independence of prior cigarette initiation and current alcohol use to grade and gender demonstrated the wide application of the gateway hypothesis. However, there were ethnic differences in the association between prior cigarette use and current alcohol use. Indian and Vietnamese students demonstrated the highest risk level for alcohol use based on past cigarette use. Furthermore, multiethnic group similarities were displayed. Subjects of Mexican or South and Central American origin had similar risk ratios, while those of Chinese, Japanese, Korean, or Filipino origins had similar risk ratios. The study was limited by an Asian-heavy sample, lack of data on age of onset of both cigarette and alcohol use, and language-proficiency issues concerning the self-reported data.

Morrall et al. (2002) constructed a model of US adolescent drug initiation and progression based on household surveys of drug use from 1982 to 1994. They examined whether or not the gateway effect of marijuana could be explained by drug use propensity as a common influence over both marijuana and hard drug use. The model reproduced the main phenomena associated with the gateway effect, e.g. elevated relative risk of hard drug initiation in marijuana users, the ordering of drug progression with marijuana as a starting or near-starting point, and the association between frequency of marijuana use and risk of hard drug initiation. The model also

produced a strong dose-response relationship between frequency of marijuana use and hard drug initiation. In the simulation, drug propensities were defined parameters and controlled for, demonstrating that drug use propensity indicators must be virtually perfectly correlated with actual drug use propensity to eliminate strong relationships between marijuana and hard drug use. In short, although the study recreates the phenomena of the gateway effect, it also demonstrates an alternate model that accounts for the propensity in general to do drugs, in addition to the variance in age of exposure to drugs.

Hall and Lynskey (2005) conducted a comprehensive review evaluating competing explanations of three of the most common relationships found between marijuana and illegal drug use: marijuana use precedes illegal drug use, earlier age of onset of marijuana use increases risk of illegal drug use, and higher frequency of marijuana use increases risk of illegal drug use. The explanations examined were: (1) the shared market for illicit drugs and marijuana increases likelihood of illicit drug use in relation to marijuana use; (2) those that use marijuana have characteristics that increase propensity for illicit drug use; and (3) the pharmacological effects of marijuana establish a casual relationship in the brain that increases propensity for illicit drug use. The association between marijuana use and illicit drug use was explained at least in part: (1) increased marijuana use in subjects with certain traits (possibly genetic) predispose them to further drug use; (2) the setting and peer group associated with marijuana use increases exposure opportunities to other drugs; and (3) socialization into an illegal drug subculture includes accepting attitudes towards illicit drug use. Frequent and early marijuana use were shown to demonstrate strong

association with illicit drug use; marijuana also demonstrated more specificity for illicit drug use than did alcohol or tobacco. Animal studies provided support for the pharmacological explanation of progression from marijuana to illicit drugs.

Patton et al. (2005) conducted a 10-year, 8-wave cohort study to determine the reverse gateway effect risks posed by marijuana use on tobacco use disorders. The study began with participants aged 14 to 15, and consisted of computerized, self-reported questionnaires and Computer-Assisted Telephone Interviewing (CATI) assessment in later waves; nicotine dependence was measured in waves 7 and 8 using the Fagerström Test [see Fagerström, Heatherton, & Kozlowski, 1991]. The survey also detailed alcohol use, depression and anxiety, antisocial behavior, and physical inactivity. They found that in teen nonusers of tobacco, weekly marijuana use in one or more waves predicted an eight times greater smoking prevalence at waves 7 and 8. Marijuana use predicted nicotine dependence independent of confounders such as smoking status and subsyndromal nicotine dependence. Marijuana use also had a moderate association with later alcohol dependence, although far less than that with tobacco. The study was limited by non-response, dropout rate, and the inability to distinguish whether or not marijuana use occurred simultaneously with tobacco use.

Bretteville-Jensen et al. (2008) constructed a multivariate probit model to examine the gateway effects of a surveyed sample of 21-30 year olds in Oslo. They acknowledged that it is unclear whether the typical sequential pattern of drug use is due to the gateway effects of specific drugs or risk factors for drug use such as accessibility to drugs and proneness of certain individuals to drug usage. Potential risk factors such as gender, age of use onset, and community drug prevalence were

considered in relation to substance use. They found that in general, usage of alcohol precedes marijuana, which precedes amphetamine, cocaine, heroin, and other hard drug usage. No gender differences were noted for the probability of cocaine or amphetamine use, although males had a higher probability of becoming frequent marijuana users. Self-reported problems with parents, school, and the police all demonstrated association with frequent drug use. Early age of onset was found to have a significant effect on probability of later hard drug usage. Acknowledged limitations included the exclusion of individual-specific factors not accounted for by the survey, as well as underrepresentation of specific groups such as the homeless and institutionalized.

It is important to note that the majority of these studies found that drug users among the test subjects followed the path of gateway drug progression. However, these studies examined possible contributing factors to the gateway progression in addition to monitoring drug use. Psychological factors were found to be associated with drug use. For example, behavioral and conduct disorders were found to be associated with cigarette and alcohol use, which strongly predicted marijuana use (Clark et al., 1998). Clark et al. also demonstrated the influence of family environment; early adolescents with fathers with substance abuse disorders were more likely to have tried tobacco. Subjects who described themselves as aggressive, easily irritable, or solitary were found to be related to substance use (Challier et al., 2000). It is thus possible that a certain personality type exists that is more susceptible to drug use and other addiction-related behavior. Rather than drug use itself causing progression, it is plausible that a certain personality would gravitate towards harder

drug use. Social and cultural factors may also play a role in proclivity to drug use. Upbringing and family environment were found to be related to substance use, especially in cases of parents with substance abuse disorders and broken families.

In short, the gateway hypothesis is far from a proven truth. The preceding studies have shown the potential viability of alternate explanations of drug use. The gateway progression of drug usage may fall under the umbrella of a propensity towards risk-taking behavior. The mechanics of drug use must be examined further in order to devise more efficient anti-drug policies as well as drug treatment strategies. This study proposes to assess the relationship between risky behavior and levels of use across different drug classes.

Chapter 3: Objectives and Hypotheses

The following objectives were established to guide the analysis of data and interpretation of results:

- To determine if there is a relationship between age of onset of drug behavior and incidence of hard drug use.
- To determine if hard drug use indicates a current or former practice of softer drug use.
- To determine if non-drug related risk behaviors are associated with hard drug use.

The dataset comprised the YRBSS national data files for 1991-2005.

Questions consistent across all eight survey years were selected from the survey, and based on the viability of data, hypotheses concerning each question's relation to later drug use were made:

- Hypothesis 1: The researchers expect to find support for the gateway drug hypothesis through two methods. They believe it will be shown that earlier onset of drug behavior is related to a higher incidence of harder drug use. They also believe that harder drug use will only be reported when softer drug use is reported as well.
- Hypothesis 2: The researchers also believe, however, that the gateway drug hypothesis will not be a sufficient explanation and that looking at non-drug related risk behaviors will paint a more complete picture. The researchers predict that non-drug related risk behaviors will show a similar relationship to

hard drug use that soft drug use does. This similarity in relationship would indicate that soft drug behavior is not a unique predictor of harder drug behavior but instead there might be an overall predisposition towards risk taking in general which would offer a more comprehensive explanation.

Chapter 4: Methods

4A - Youth Risk Behavior Surveillance System

The Youth Risk Behavior Surveillance System was developed in response to the Centers for Disease Control and Prevention (CDC) interest in HIV prevention programs in schools and their need for data that described risk behavior among youth. It was designed specifically to monitor the prevalence of health risk behaviors and provides national, state, local, and subpopulation data. The following section refers to “Methodology of the Youth Risk Behavior Surveillance System” (Centers for Disease Control and Prevention, 2004).

The questionnaire was built around available data on the leading causes of young adult death in 1988: 55% of deaths were a result of motor vehicle accidents, homicide, or suicide, while the remaining 45% were due to all other causes of death. Reported changes have been minimal since that time. The general categories of risk behaviors include physical inactivity/obesity, dietary habits, sexual behavior, tobacco use, alcohol and other drug use, violence, and unintentional injury. The survey was piloted in October 1989 and was reviewed by the education agency from the District of Columbia, 16 local education agencies, four U.S. territories, and each state. The survey also was evaluated by the National Center for Health Statistics (NCHS) survey research specialists. A revised version was administered in the spring of 1990 to a national sample, 25 state samples, and nine district samples. This survey was also sent to the Questionnaire Design Research Laboratory at the National Center for Health Statistics (NCHS) for lab and field evaluation. In October 1990, a new version was

issued that added questions for evaluating the national health objectives. The revised tool also took into account Spring 1991 data from the CDC, and state and local education agencies, and input from reviewing committees. Reliability reviews in 1992 and 2000 resulted in the removal or modification of unreliable items. In 2003, the CDC conducted a literature review to determine if there were situational or cognitive factors that might affect the validity of the adolescent self-reported data; the Centers found that cognitive and situational factors did not pose a threat to self-report validity.

The nationally representative sample is obtained utilizing a three-stage, cluster sample design. The national school-based survey has conducted under contract with Macro International since 1990. Following CDC guidelines, the contractor is responsible for designing and selecting the sample, scheduling data collection, obtaining parental permission, hiring and training data collectors, weighting the data, and preparing the data for analysis. Sample sizes are constructed to produce estimates accurate to $\pm 5\%$ at 95% confidence, including estimates for the subgroups grade, gender, race/ethnicity, grade by gender, and race/ethnicity by gender. Similarly, estimates are accurate to $\pm 5\%$ at 90% confidence for grade by race/ethnicity subgroups.

The first sampling stage consists of primary sampling units (PSUs), each a large-sized county or a group of adjoining smaller counties. Counties large enough have been subdivided into sub-PSUs since the 1999 survey. PSUs are then selected from 16 strata and sorted by percentages of black and Hispanic students and metropolitan statistical area (MSA); metro areas contain a core urban area with a

population of at least 50,000.

The second sampling stage involves selecting schools from PSUs based on the Common Core of Data of the National Center for Education Statistics and the Quality Education Database (US Department of Education, 2004; Quality Education Data, 2004). The list of schools includes whole schools that contain grades 9-12, and fragment schools without all four grades; these are combined with other fragment schools to create cluster schools. Large schools are defined as having enrollment of 25 or more students per class, while small schools have an enrollment of less than 25 students per class. Roughly one fourth of PSUs are selected for small-school sampling, in which one small school is selected within each of these PSUs. Three large schools are selected from each sampled PSU. In the third and final stage of sampling, one or two classes from each grade in each sampled school are selected at random.

Three methods are utilized to oversample black and Hispanic students for separate analysis: larger sampling rates for PSUs with higher populations of students of these ethnicities, using a modified measure of size that increases the probability of selecting an ethnically-rich school, and selecting two classes per grade rather than one in ethnically rich schools. Then, a weight is applied to each record based on gender, race/ethnicity, and grade in order to prevent oversampling of black and Hispanic students in the overall dataset. Weights exceeding a criterion value are trimmed and redistributed among unedited values in order to combat large sampling variances [see Potter, 1990]. Final weights are scaled so that the weighted counts equal the total sample size and that the proportions of subgroups match national population

projections. Sampled units that decline participation are not replaced in order to prevent bias.

Trained personnel at the national, and most state and local sites, administer the survey after an introduction. The personnel read standardized scripts, administer the survey, and record defined, descriptive information regarding schools and classrooms. Make-up sessions are provided for students who are absent; this partially corrects for absentee students who are more likely to engage in risky behaviors.

The national dataset is compiled by ORC Macro and sent to CDC for data cleaning and editing for logical consistency, missing data, and out-of-range responses. Questionnaires with less than 20 valid responses after the application of logical edits are removed. Edited data are sent to ORC Macro for weighting as described above. The final dataset is compiled by CDC from the weights provided by ORC Macro.

One of the inherent limitations of the questionnaire is that the data is elicited through self-report, so it is impossible to verify the accuracy of a respondent's answers. In addition, permission procedures are locally determined and not nationally uniform, and state-level data is not available for all states. The unweighted data represents only those students who complete the survey, and it is possible that it is precisely those students who have not participated in the process who are the same ones engaging in the majority of risky behaviors

4B - Determining and Testing of Hypotheses

The surveys varied from year to year so the researchers first needed to determine which items were present across all years. To accomplish this task the

researchers charted the survey items and recorded which the years in which each item was present. After completing this task it was determined that thirty-seven questions were present in every year. The researchers decided it would be best to focus on the items present across all years so that they could determine if any discovered relationship changed over time. For a complete list of items present across all years please see Appendix A. The researchers looked through the thirty seven items to find those that examined age of onset for risk behavior as well as frequency of risk behaviors. The researchers decided to examine the questions: 1) how old were you when you have your first drink of alcohol other than a few sips; 2) how old were you when you tried marijuana for the first time; 3) during your life, how many times have you used any form of cocaine including powder, crack, or freebase; 4) how old were you when you had sexual intercourse for the first time; 5) how old were you when you smoked a whole cigarette for the first time; and 6) during the past 12 months, how many times were you in a physical fight.

In order to examine evidence of support for the gateway drug hypothesis the researchers looked at age of onset of risk behaviors and how those related to incidence of cocaine use. The researchers graphed what percentage of participants in each onset group had used cocaine 0 times, 1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, and 40 or more times. This was done separately across all years for age of first cigarette consumption, age of first alcohol consumption, and age of first marijuana consumption. The researchers felt that earlier gateway drug use leading to higher incidence of cocaine use would lend support to the gateway drug hypothesis.

The gateway drug hypothesis was also examined by looking at what

percentage of people who had tried cocaine had tried and had not tried the gateway drugs being studied (tobacco, alcohol, marijuana). This was accomplished by conducting cross tabulations between the incidence of cocaine use variable and the variables looking at gateway drug age of onset. The researchers looked at the percentage of question respondents who had indicated that they used both the gateway drug and cocaine as well as the percentage of respondents who indicated that they had used cocaine but not the gateway drug. For this examination the researchers did not look into how often cocaine was used or age of onset of gateway drug use, instead looking only at tried versus had not tried for both categories of questions. If the gateway drug hypothesis were true across all cases then the researchers expected that those people who had responded that they had tried cocaine would also indicate that they had tried the various gateway drugs, since the hypothesis believes that drug users move on a continuum from less serious to more serious drugs- the most serious drug in the study being cocaine.

In order to examine the possibility that drug behaviors follow a trend consistent with a risk taking personality the researchers looked at how age of first alcohol consumption, age of first cigarette consumption, age of first marijuana consumption, age of first sexual intercourse, and number of times in a physical fight were related to whether or not the participant had ever tried cocaine. The researchers converted the item measuring incidence of cocaine use to a binary variable recording whether or not the participant had tried cocaine. This process was used in order to determine if there was a relationship between early and frequent demonstration of risk behaviors and whether or not the participant would try something risky (i.e. cocaine)

once versus forming a habit as the gateway drug theory would dictate.

The researchers then graphed what percentage of people in each response group had tried cocaine, this was done across all years. The researchers then ran bivariate Pearson correlations between percentage in group who had tried cocaine and age of onset of the targeted risk behavior or in the case of times in a physical fight the frequency of the risk behavior [see Kinnear & Gray, 2008]. Two way ANOVAs were also run to determine the effect of year as well as risk behaviors on likelihood of trying cocaine and to determine if there was an interaction effect between year and age of onset or frequency of risk behaviors [see Kinnear & Gray, 2008].

Question response rates are shown in Table 1. The lowest response rate was 87 percent in 2003 for the Age of First Sexual Intercourse item. The majority of questions had a response rate in the upper nineties across all years. The percentage of people who indicated that they had tried cocaine in each year is shown in Table 2 and Figure 1.

Table 1. Question Response Rates

Year	Total Responses	Times in a Physical Fight	Age of First Cigarette Use	Age of First Alcohol Use	Age of First Marijuana Use	Age of First Sexual Intercourse	Incidence of Cocaine Use
1991	12272	99	97	92	99	95	99
1993	16296	98	98	92	99	97	99
1995	10904	98	98	93	99	95	99
1997	16262	99	98	92	99	97	99
1999	15349	98	95	91	99	94	99
2001	13601	98	98	90	98	95	99
2003	15214	96	96	90	97	87	97
2005	13917	98	97	91	98	89	99

Note. Total responses indicate the number of returned surveys. The subsequent columns indicate the percentage of the total respondents who answered the question indicated in the column heading.

Table 2. Percent of Respondents Who Tried Cocaine

Year	Percent Who Tried Cocaine
1991	6.1
1993	6.6
1995	7
1997	8.3
1999	9.6
2001	9.8
2003	6.1
2005	7.6

Note. The percentage of people who indicated they had tried cocaine. The percentage was taken from the total number of people who answered the incidence of cocaine use question.

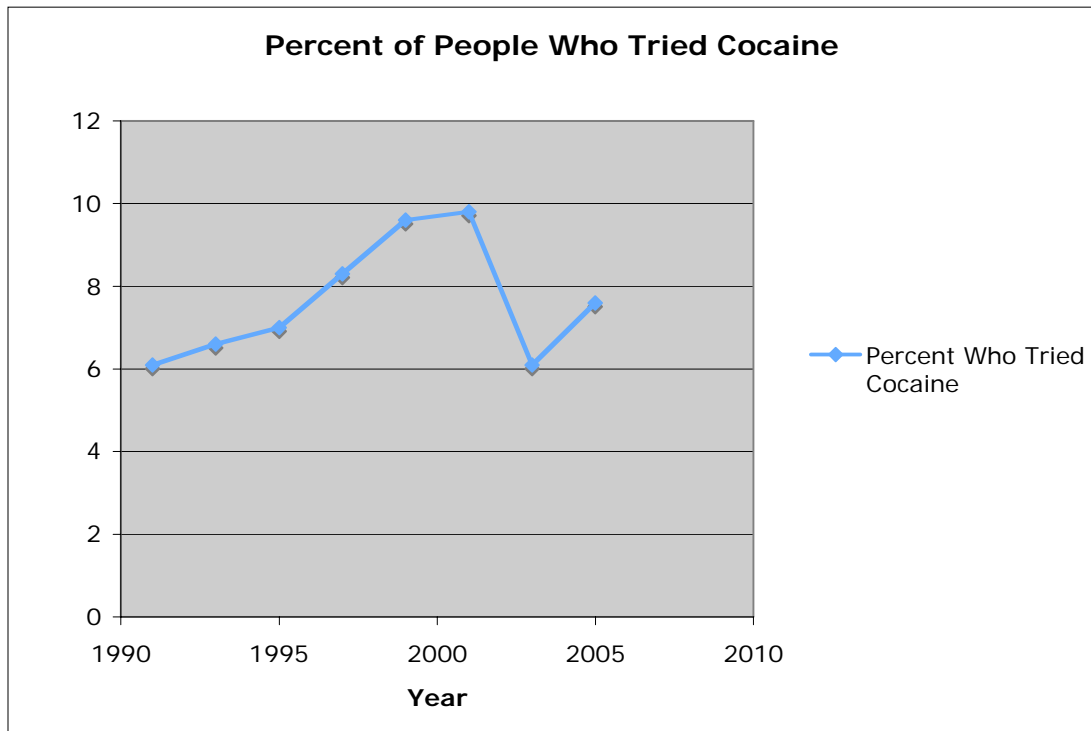


Figure 1. Graphical presentation of the data shown in Table 2.

Chapter 5: Results

The graphs for age of onset of cigarette use and incidence of cocaine use for 1991-2005 are shown in Figures 2-9. The graphs appear to show a parabolic trend among incidence of cocaine use and age of onset of cigarette use, the trend is present across all years. Most people who have tried cocaine have tried it once or twice with a decreasing tendency to try it 3-39 times. There is then an increase in the percentage of people who have used cocaine forty or more times when compared with the preceding group. It is possible that this trend speaks to the addictive properties of cocaine with many people only trying the drug a couple of times and people who partake more than that showing a likelihood to get addicted and report to have used cocaine 40 or more times. It is also important to note that subjects who reported using cigarettes when they were nine or younger showed an almost equal likelihood to have tried cocaine once or twice or to have used it forty or more times. In 1997 the subjects who used cigarettes when they were nine or younger start to show a higher likelihood of using cocaine forty or more times than they do of using cocaine once or twice, as time passes this difference increases until there is a larger disparity between the percentage of respondents in this group that have used cocaine forty or more times and the percentage of respondents who have used cocaine once or twice. These results lend support towards the gateway drug hypothesis.

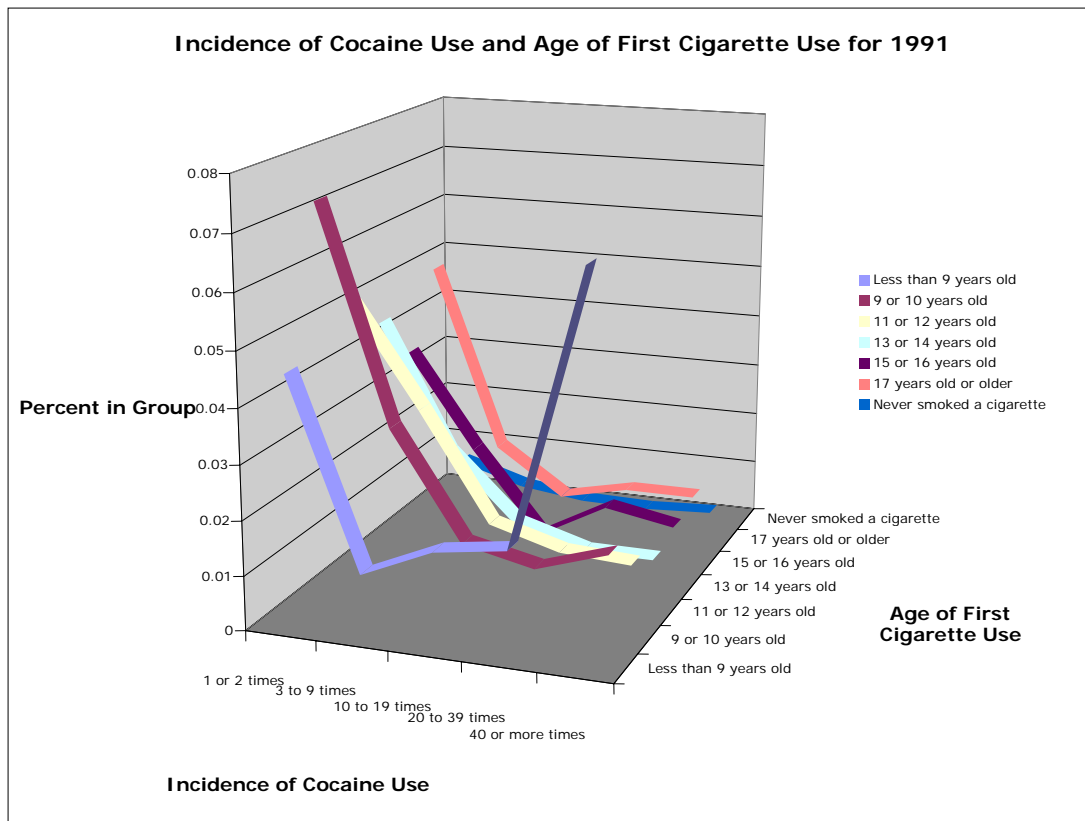


Figure 2. Plot of the percentage of people in each age group who used cocaine the indicated number of times in 1991.

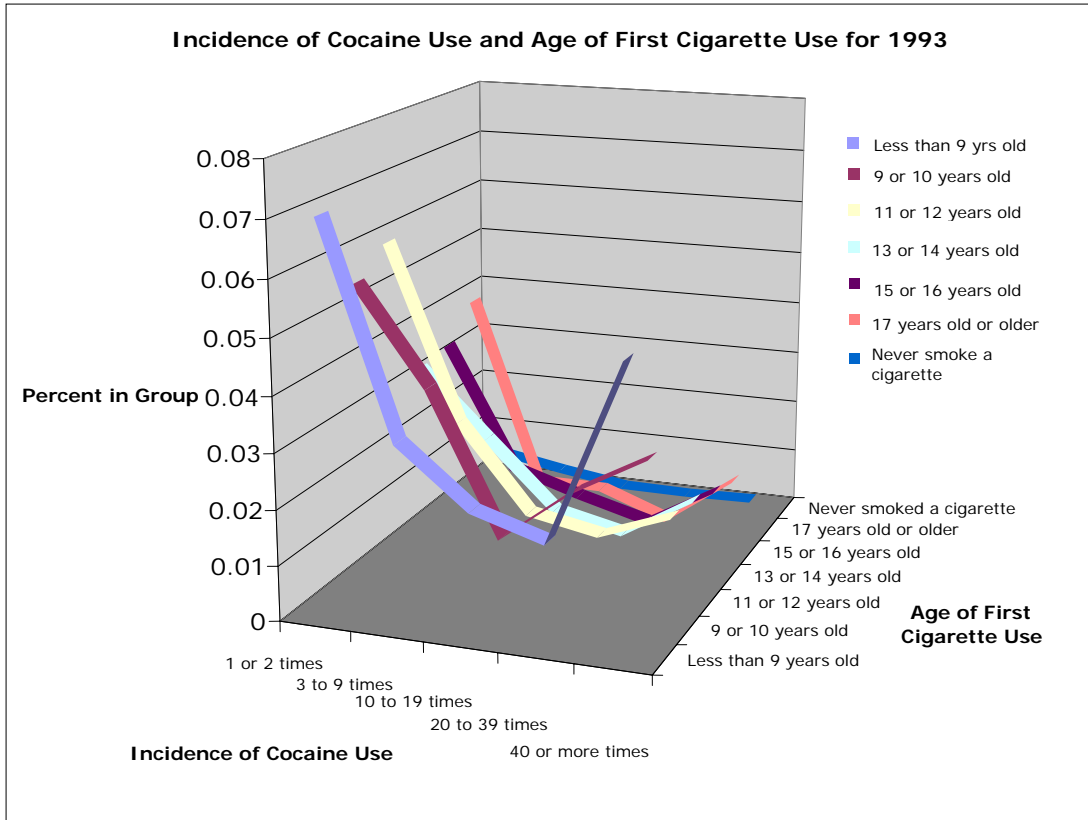


Figure 3. Plot of the percentage of people in each age group who used cocaine the indicated number of times in 1993.

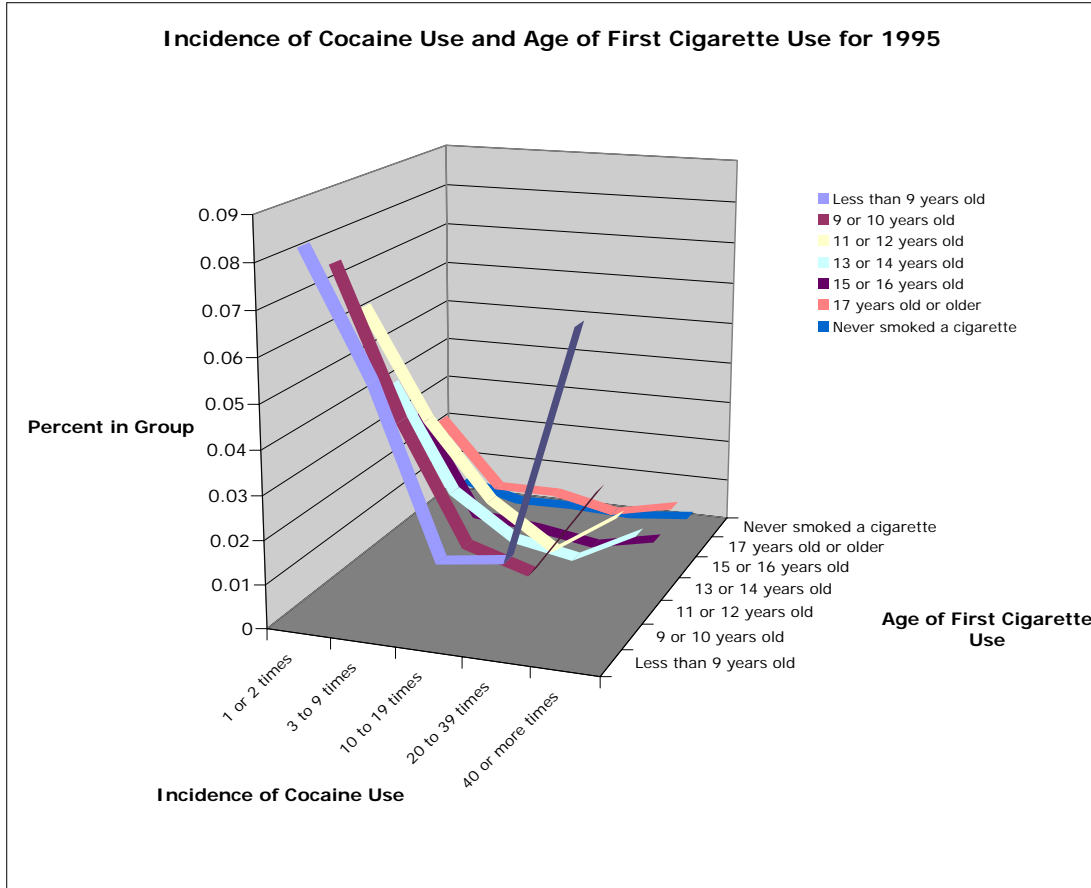


Figure 4. Plot of the percentage of people in each age group who used cocaine the indicated number of times in 1995.

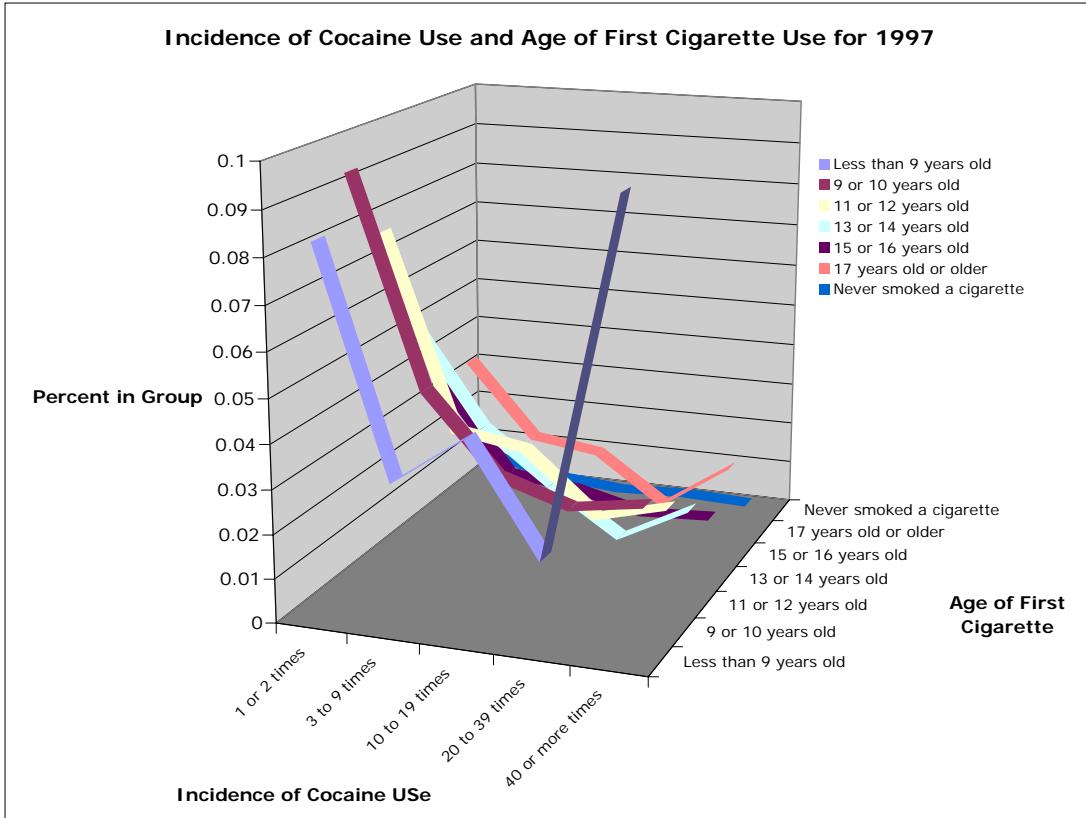


Figure 5. Plot of the percentage of people in each age group who used cocaine the indicated number of times in 1997.

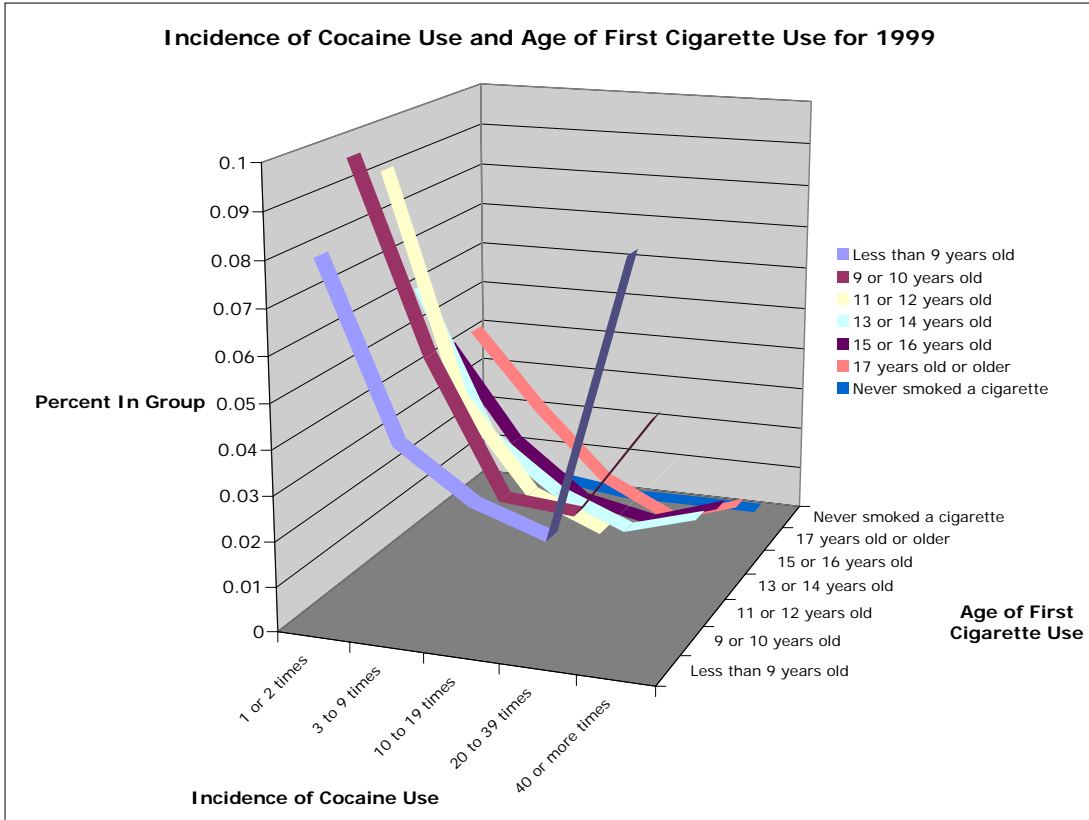


Figure 6. Plot of the percentage of people in each age group who used cocaine the indicated number of times in 1999.

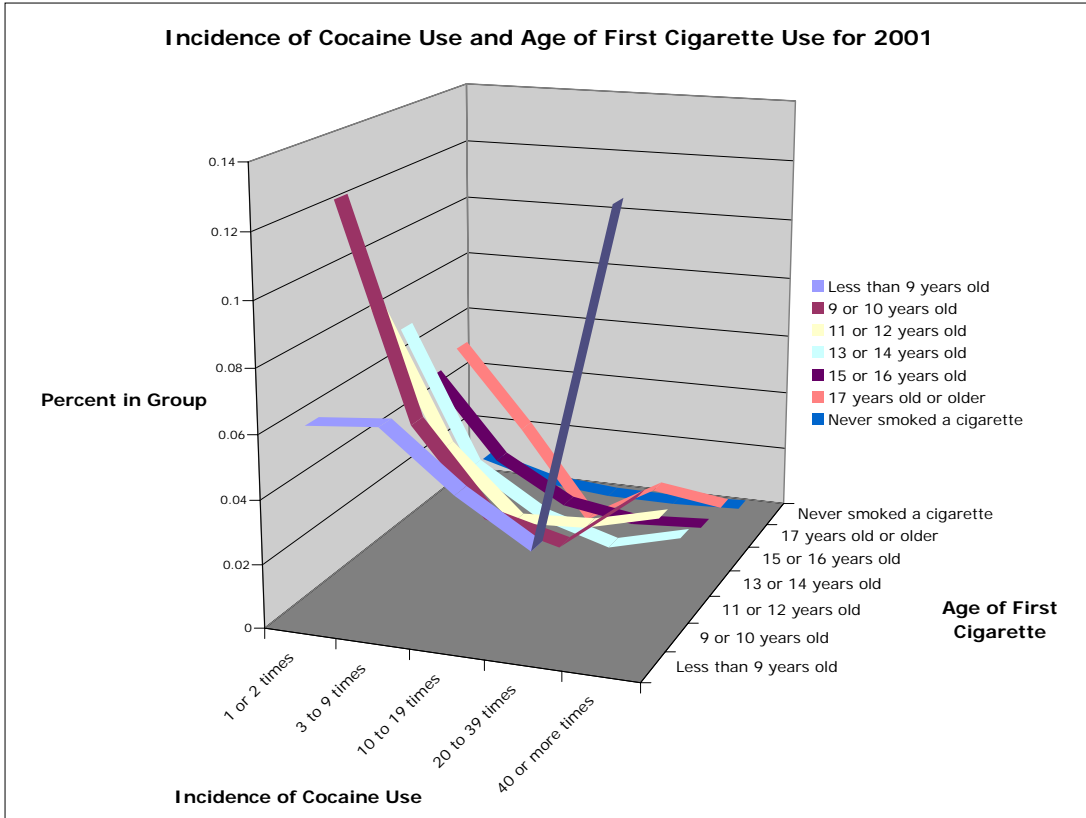


Figure 7. Plot of the percentage of people in each age group who used cocaine the indicated number of times in 2001.

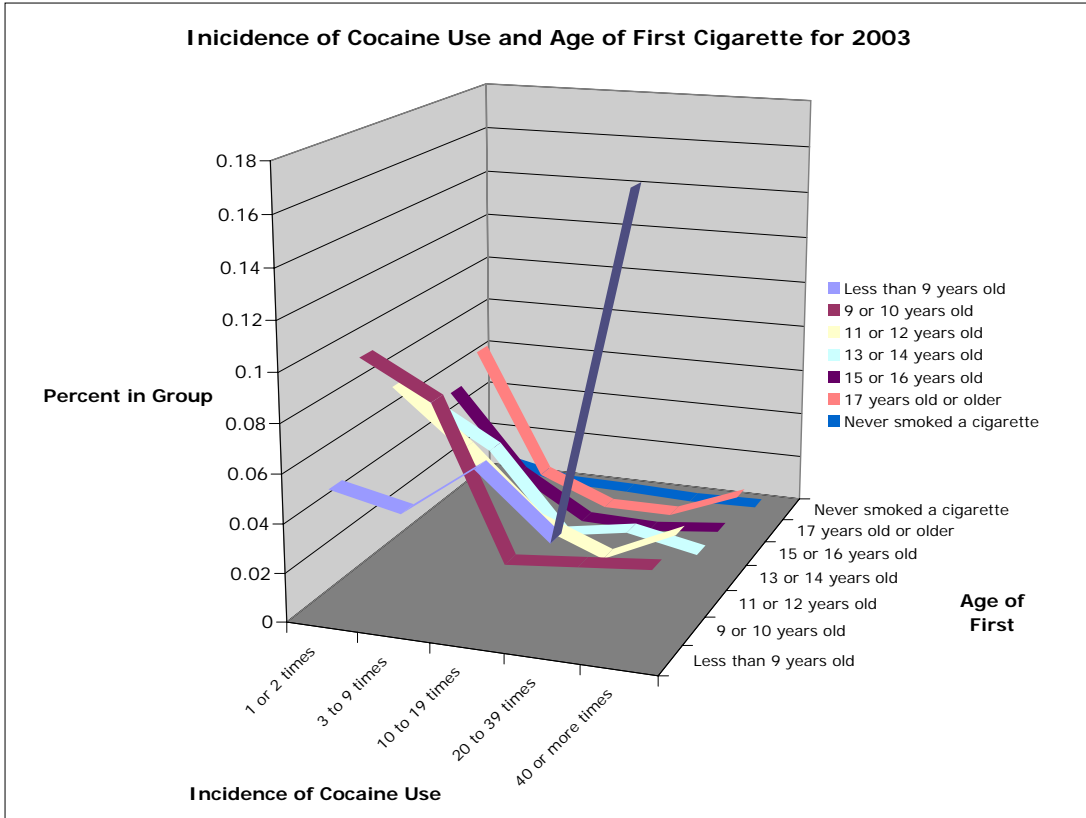


Figure 8. Plot of the percentage of people in each age group who used cocaine the indicated number of times in 2003.

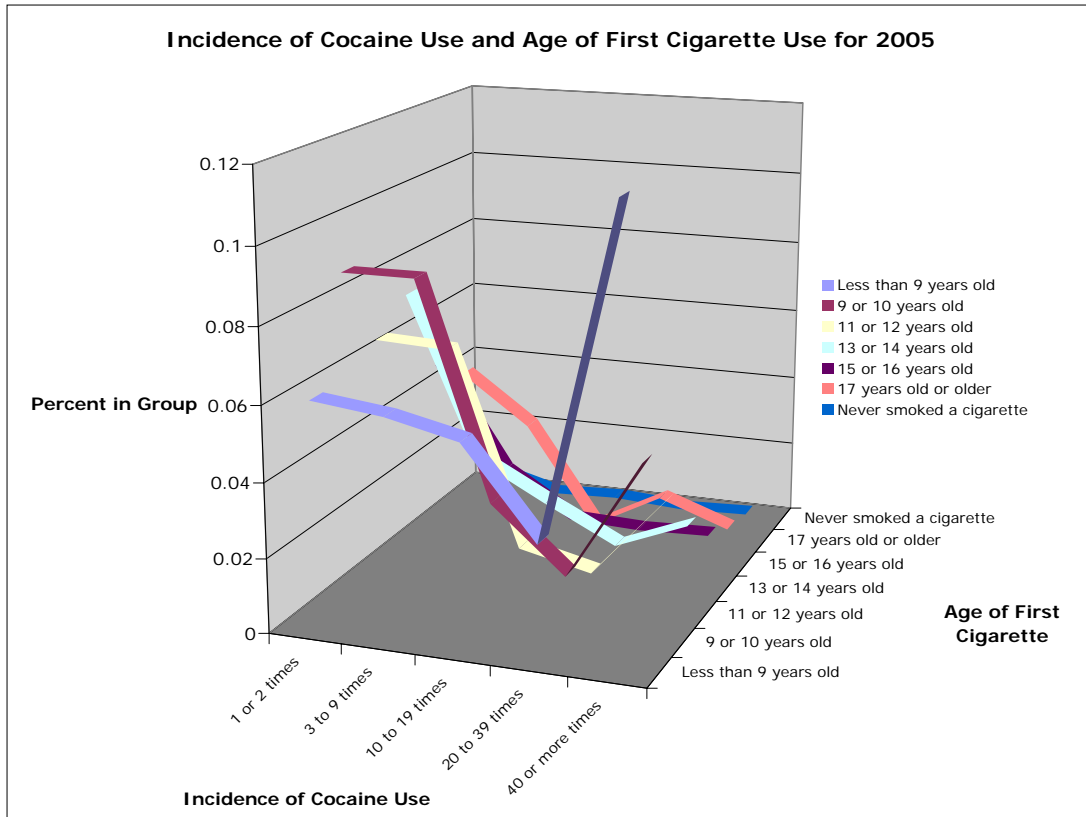


Figure 9. Plot of the percentage of people in each age group who used cocaine the indicated number of times in 2005.

The graphs for age of onset of alcohol use and incidence of cocaine use for 1991-2005 are shown in Figures 10-17. The graphs appear to show a curvilinear trend among incidence of cocaine use across years as related to age of onset of alcohol use. The trend that most people who have tried cocaine have tried it once or twice with a decreasing tendency to try it 3-39 times and then a tail increase in the percentage of people who have used cocaine forty or more times. This is a pattern similar to Figures 2-9 for cigarette use. Also similar to the findings from the graphs examining age of onset of cigarette use was the fact that subjects who reported using cigarettes when they were nine or younger showed an almost equal likelihood to have tried cocaine

once or twice or to have used it forty or more times. Unlike the findings in the cigarette use graphs where those who had an age of onset younger than nine years old showed a trend where they became more likely to use cocaine 40 or more times than once or twice, the alcohol graphs show that those who started when they were nine or younger are almost equally likely to have used cocaine once or twice or 40 or more times across all years. These results lend support towards the gateway drug hypothesis.

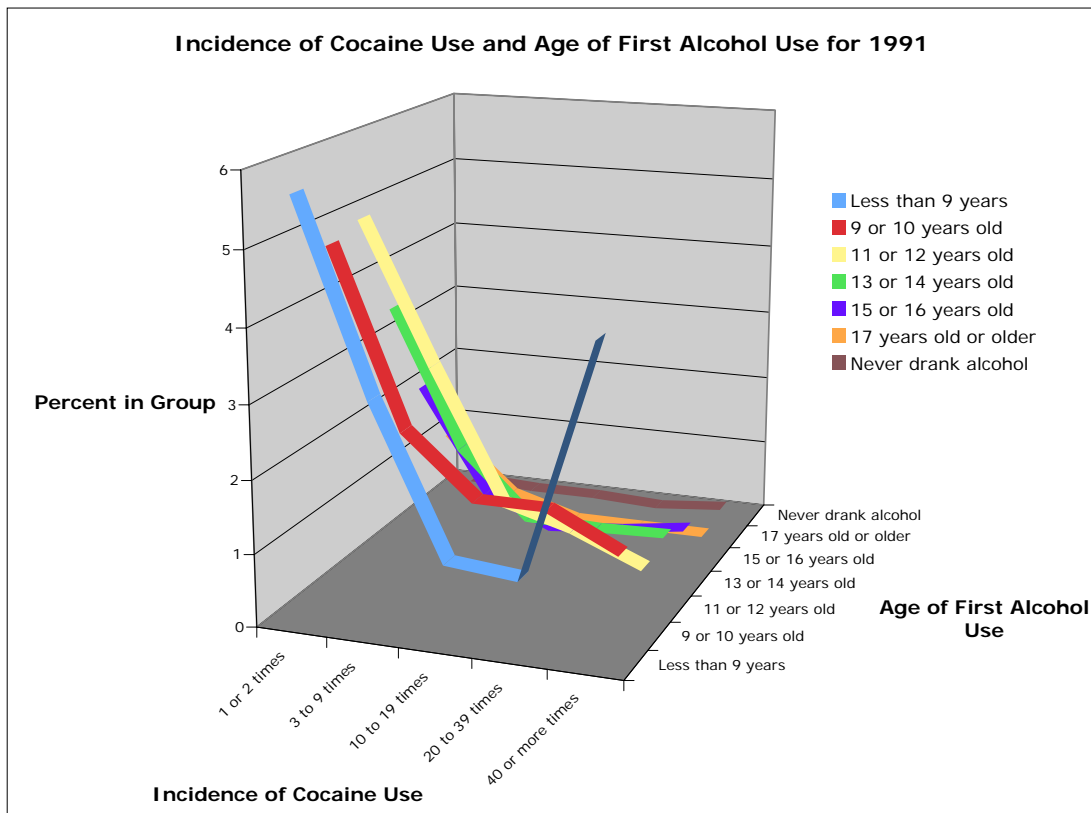


Figure 10. Plot of the percentage of people in each age of onset of alcohol use group who used cocaine the indicated number of times in 1991.

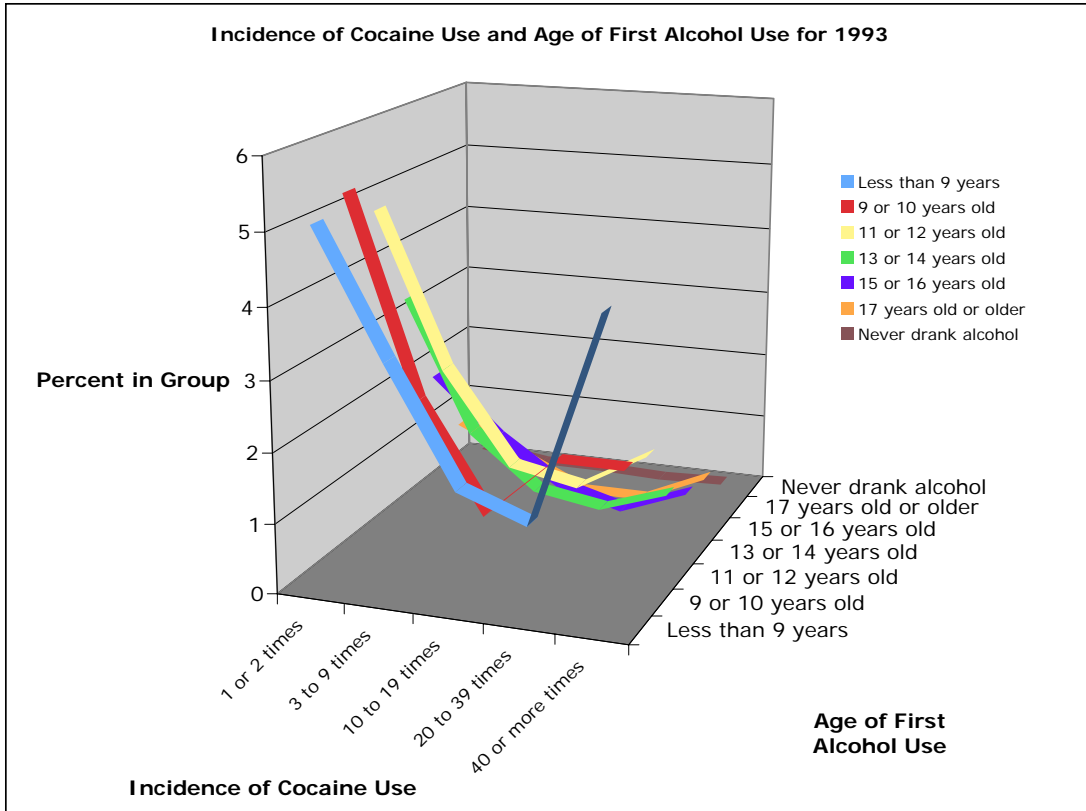


Figure 11. Plot of the percentage of people in each age of onset of alcohol use group who used cocaine the indicated number of times in 1993.

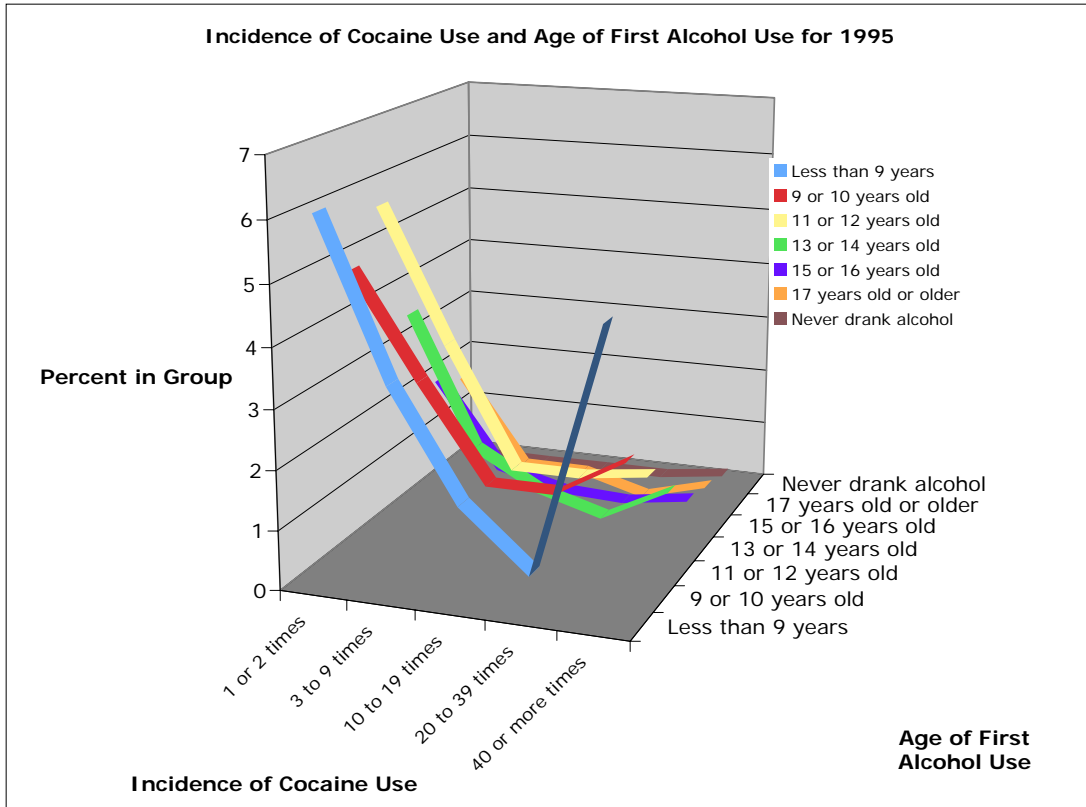


Figure 12. Plot of the percentage of people in each age of onset of alcohol use group who used cocaine the indicated number of times in 1995.

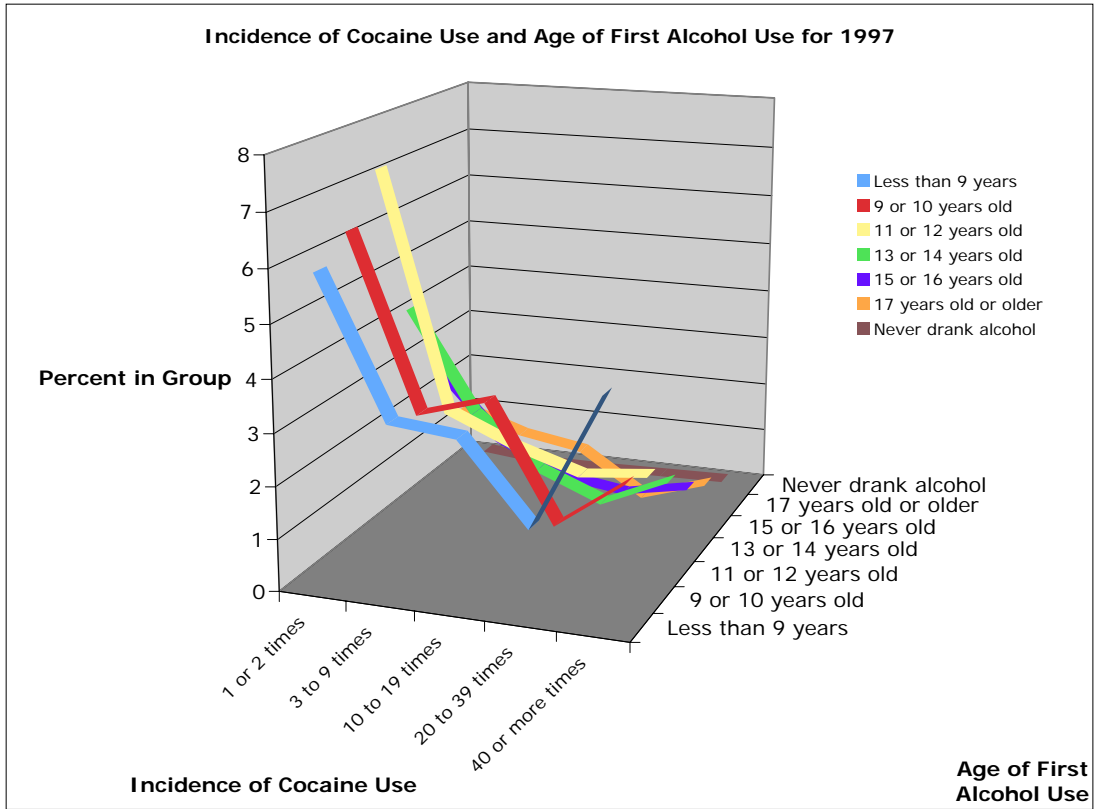


Figure 13. Plot of the percentage of people in each age of onset of alcohol use group who used cocaine the indicated number of times in 1997.

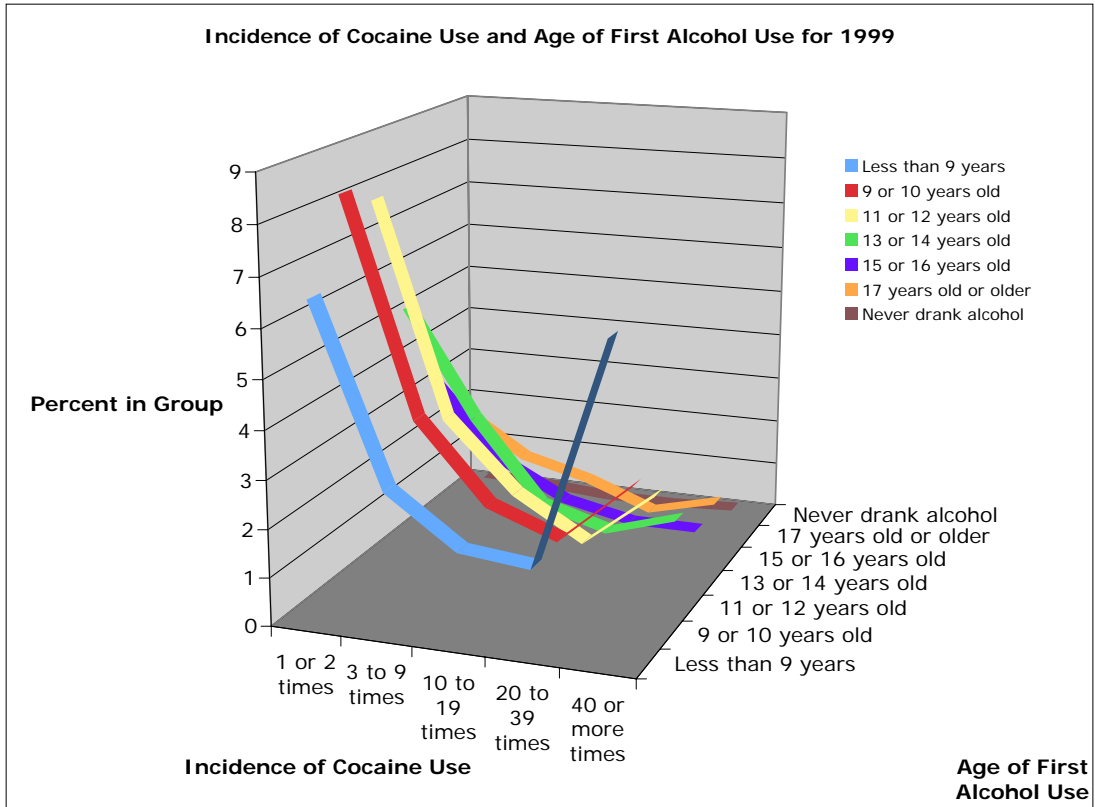


Figure 14. Plot of the percentage of people in each age of onset of alcohol use group who used cocaine the indicated number of times in 1999.

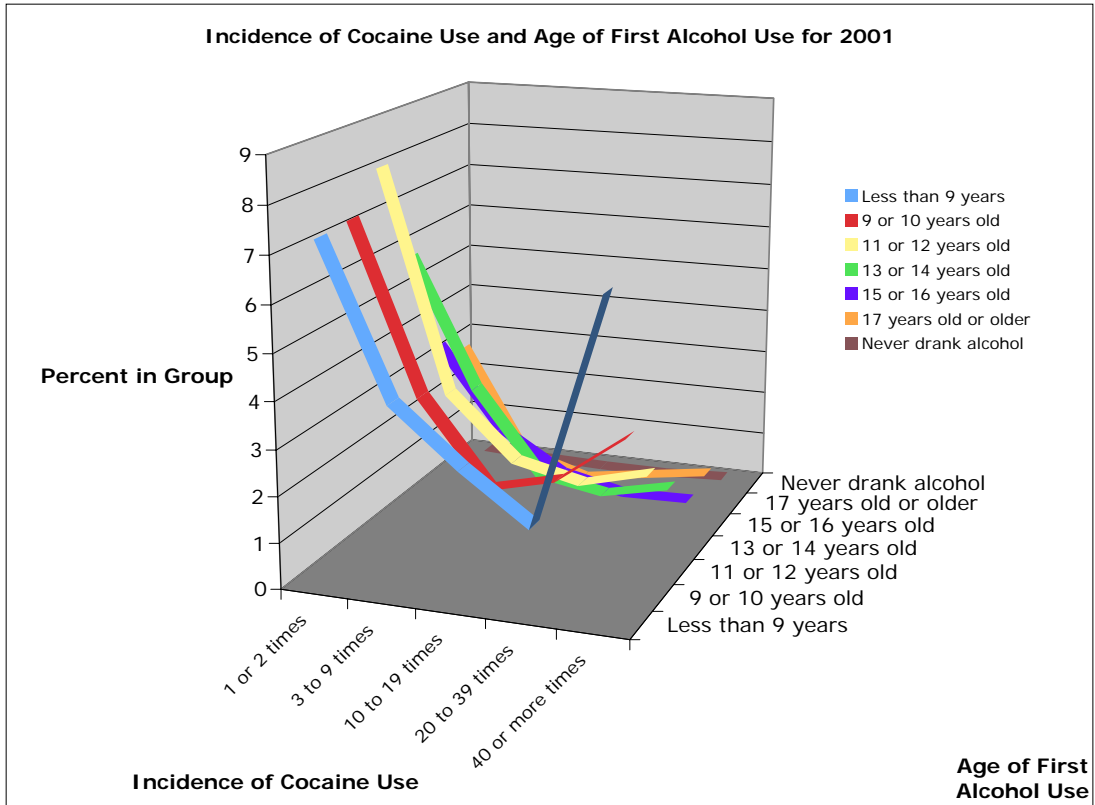


Figure 15. Plot of the percentage of people in each age of onset of alcohol use group who used cocaine the indicated number of times in 2001.

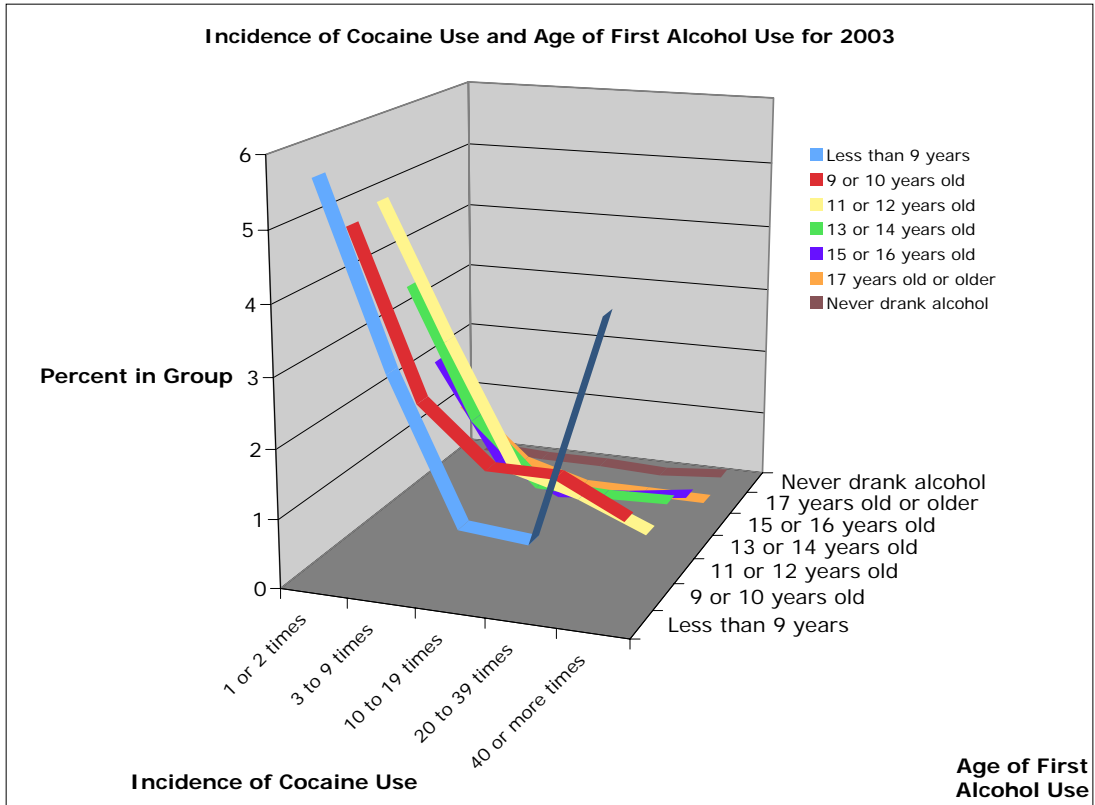


Figure 16. Plot of the percentage of people in each age of onset of alcohol use group who used cocaine the indicated number of times in 2003.

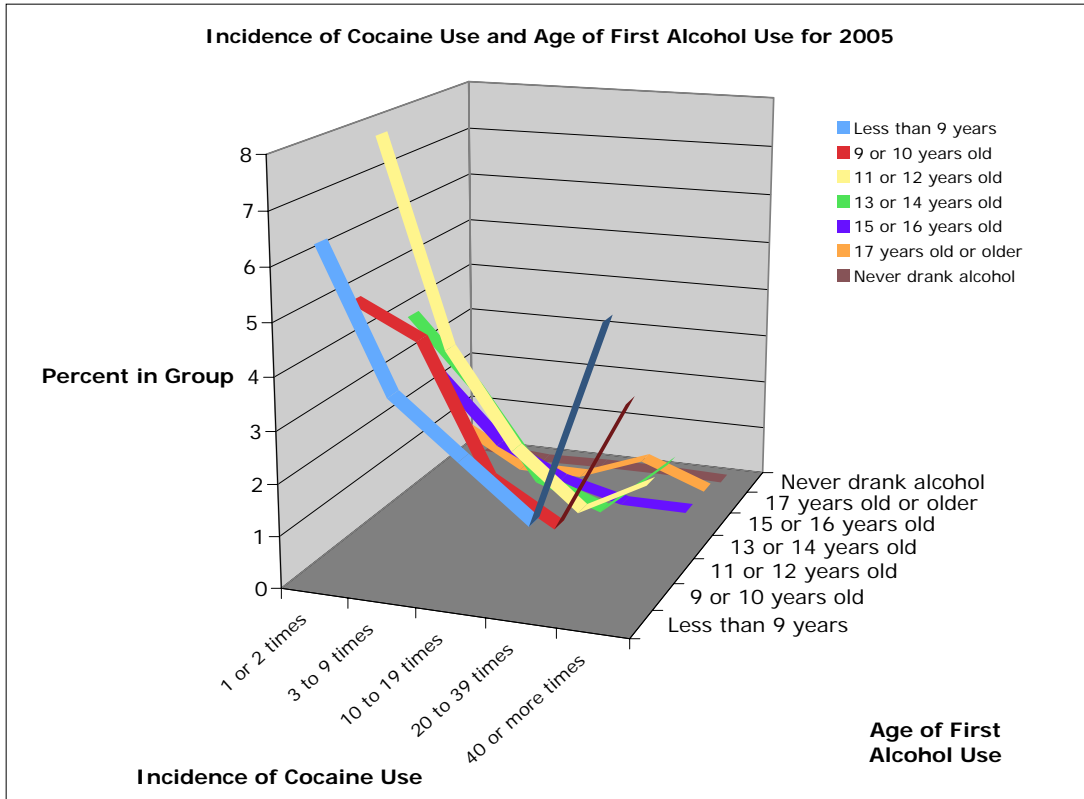


Figure 17. Plot of the percentage of people in each age of onset of alcohol use group who used cocaine the indicated number of times in 2005.

The graphs for age of onset of marijuana use and incidence of cocaine use for 1991-2005 are shown in Figures 18-25. The graphs again appear to show a curvilinear trend among incidence of cocaine use across years as related to age of onset of marijuana use. The trend is that most people who have tried cocaine have tried it once or twice with a decreasing tendency to try it 3-39 times and then a tail increase in the percentage of people who have used cocaine forty or more times. This same trend as seen with cigarette and alcohol use was seen again in the graphs examining age of onset of marijuana use. The findings were different from the graphs examining age of onset of cigarette and alcohol use in the fact that subjects who reported using marijuana when they were nine or younger showed a higher likelihood of having used

cocaine 40 or more times than once or twice across all years. In 1995 and 1993 those who had started using marijuana when they were 9 or 10 showed an equal or greater likelihood of using cocaine 40 or more times when compared with once or twice.

These results lend support towards the gateway drug hypothesis.

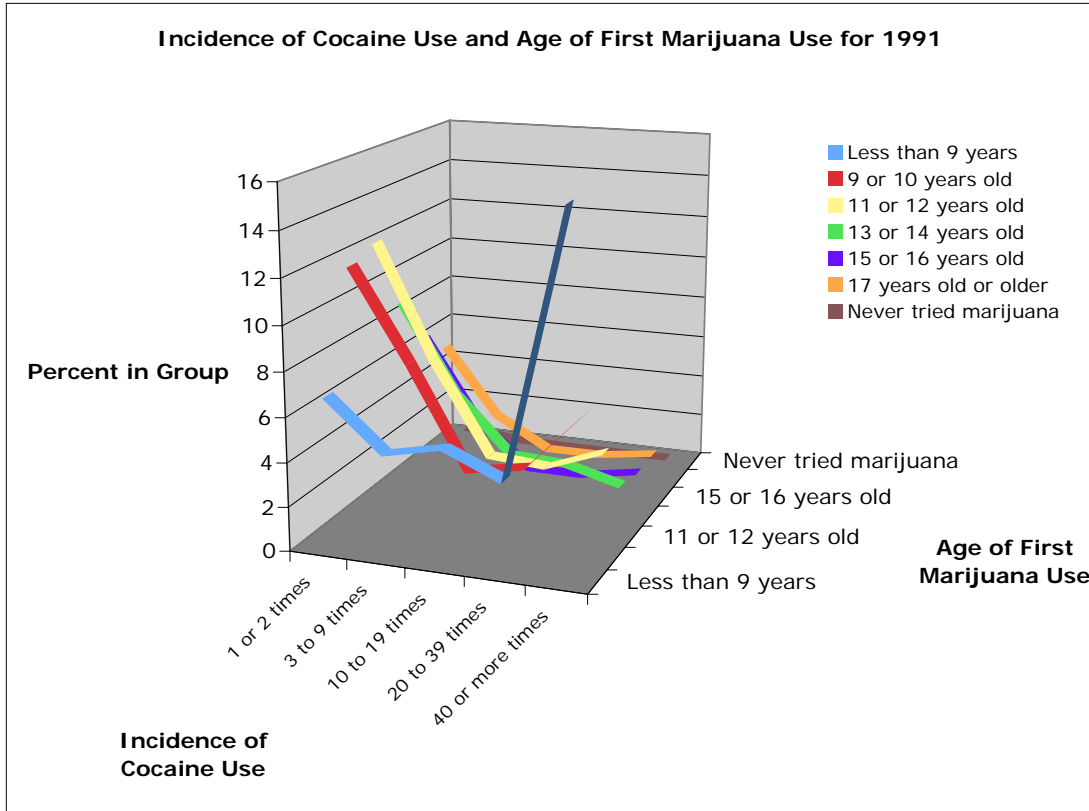


Figure 18. Plot of the percentage of people in each age of onset of marijuana use group who used cocaine the indicated number of times in 1991.

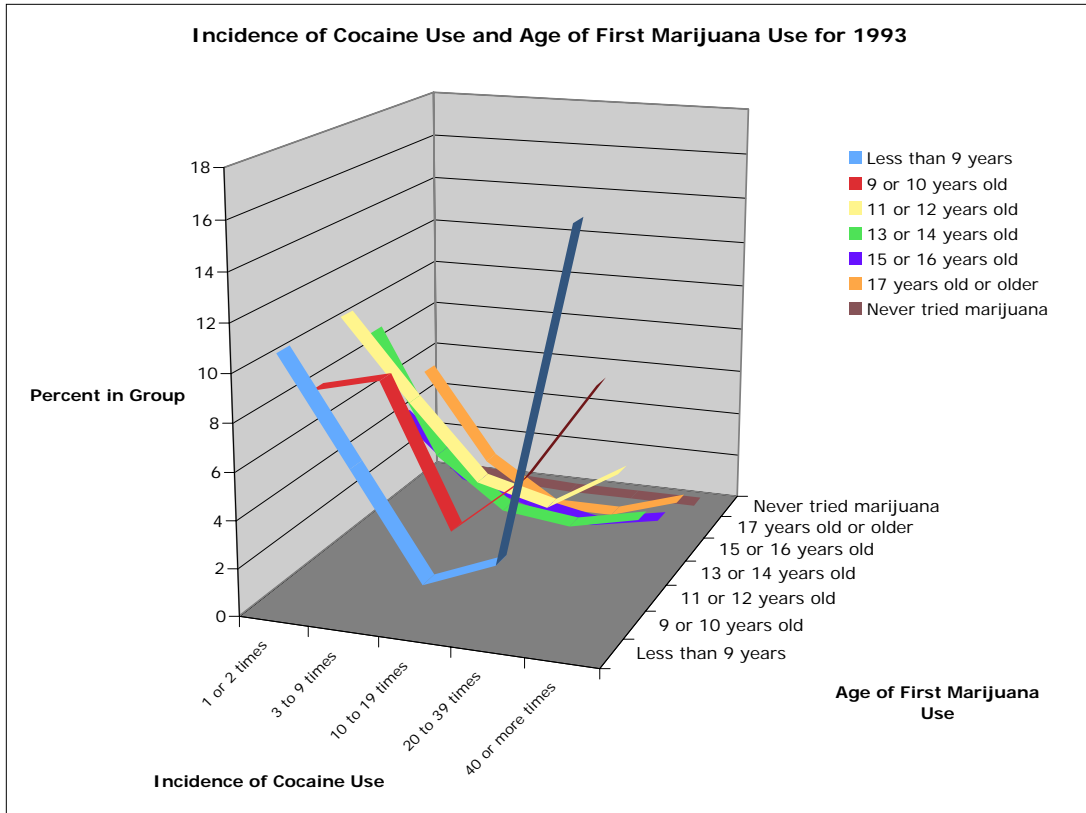


Figure 19. Plot of the percentage of people in each age of onset of marijuana use group who used cocaine the indicated number of times in 1993.

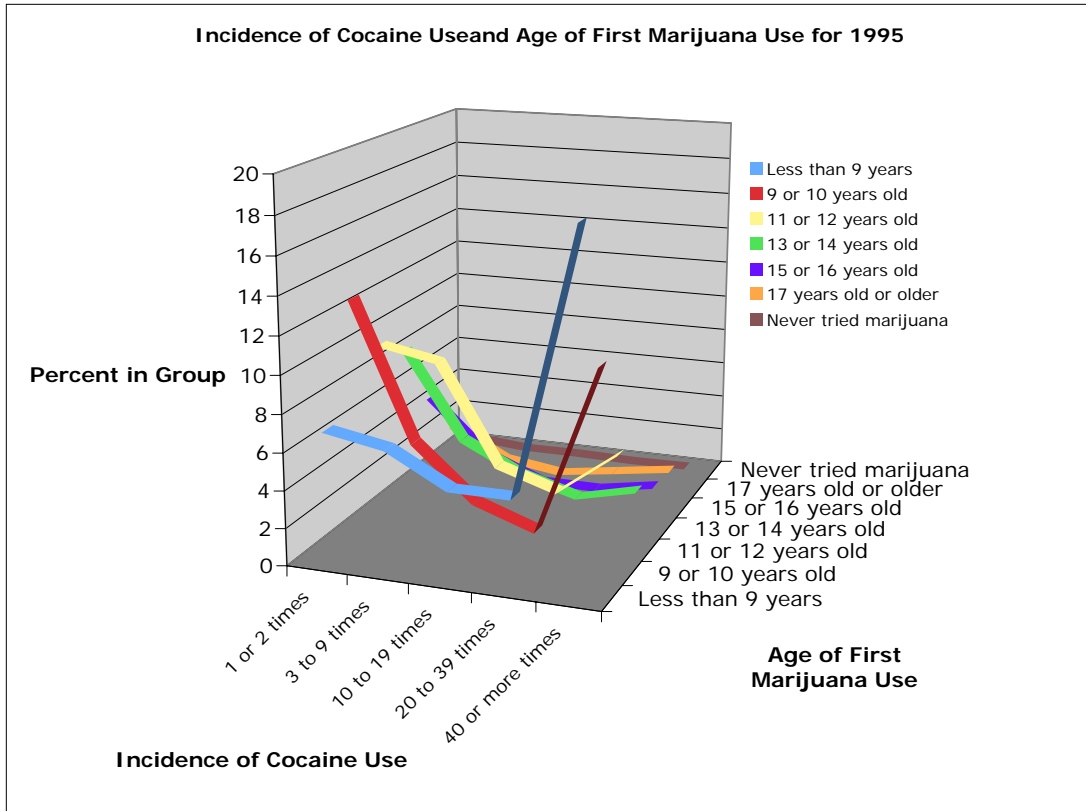


Figure 20. Plot of the percentage of people in each age of onset of marijuana use group who used cocaine the indicated number of times in 1995.

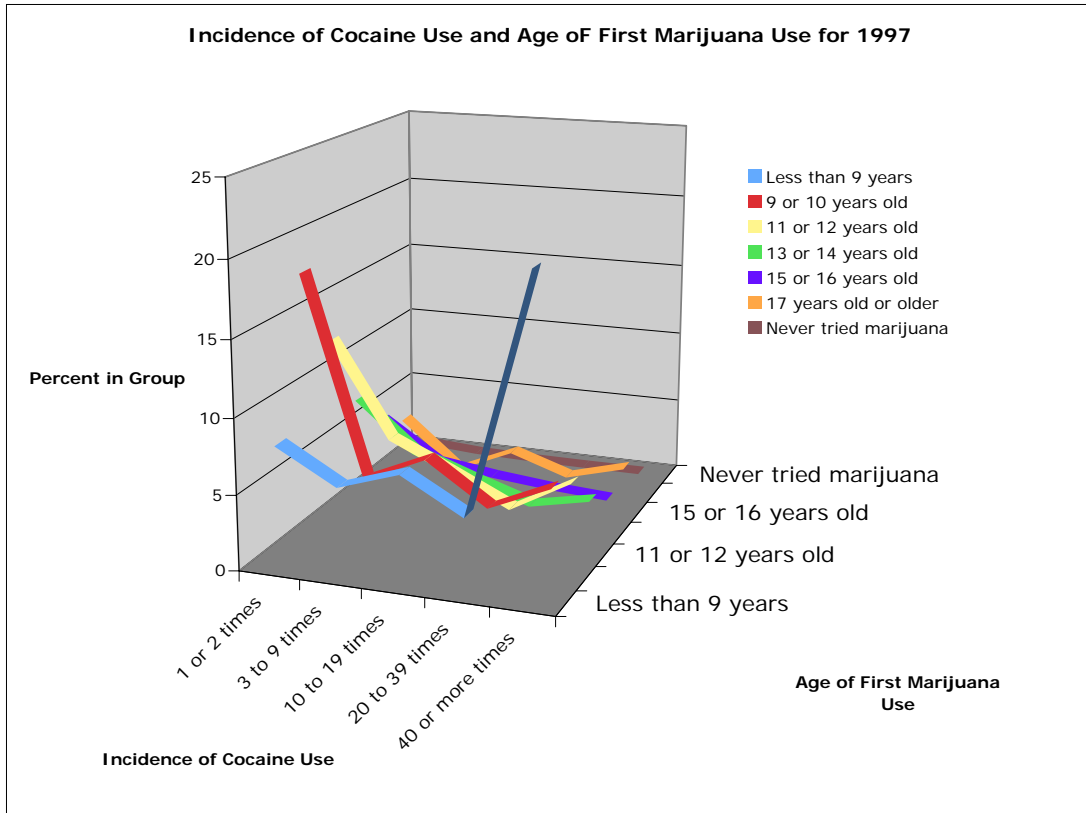


Figure 21. Plot of the percentage of people in each age of onset of marijuana use group who used cocaine the indicated number of times in 1997.

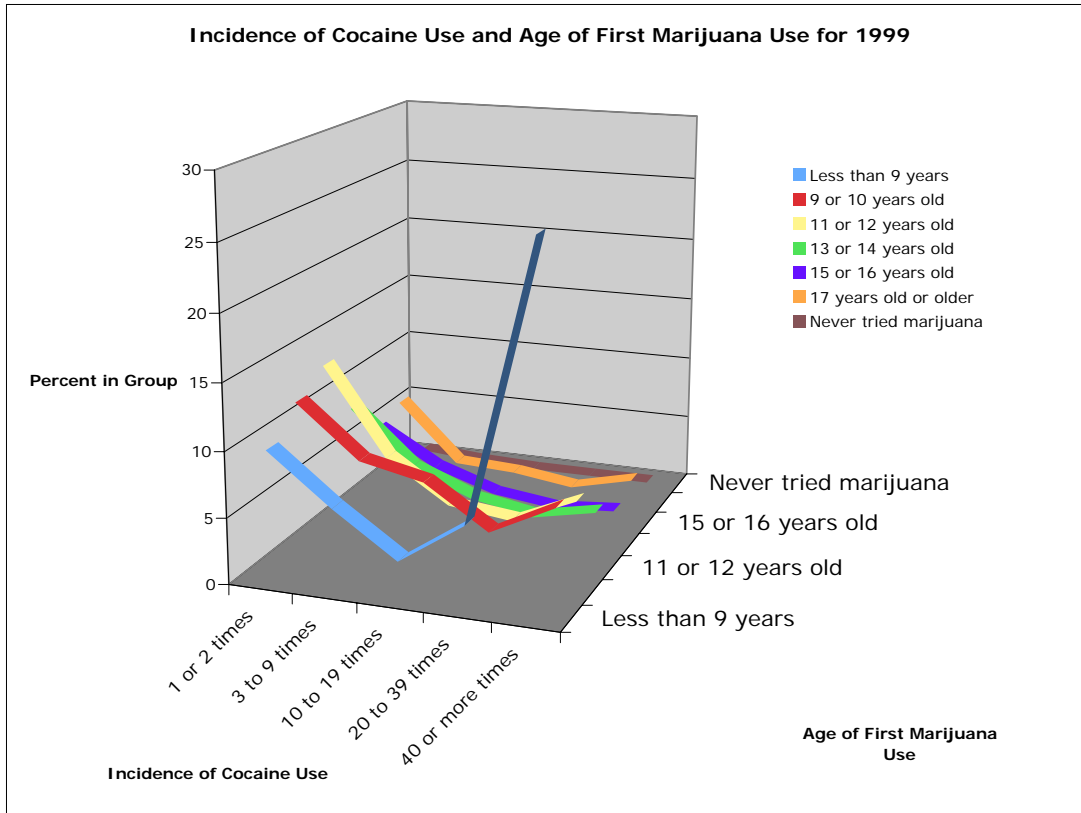


Figure 22. Plot of the percentage of people in each age of onset of marijuana use group who used cocaine the indicated number of times in 1999.

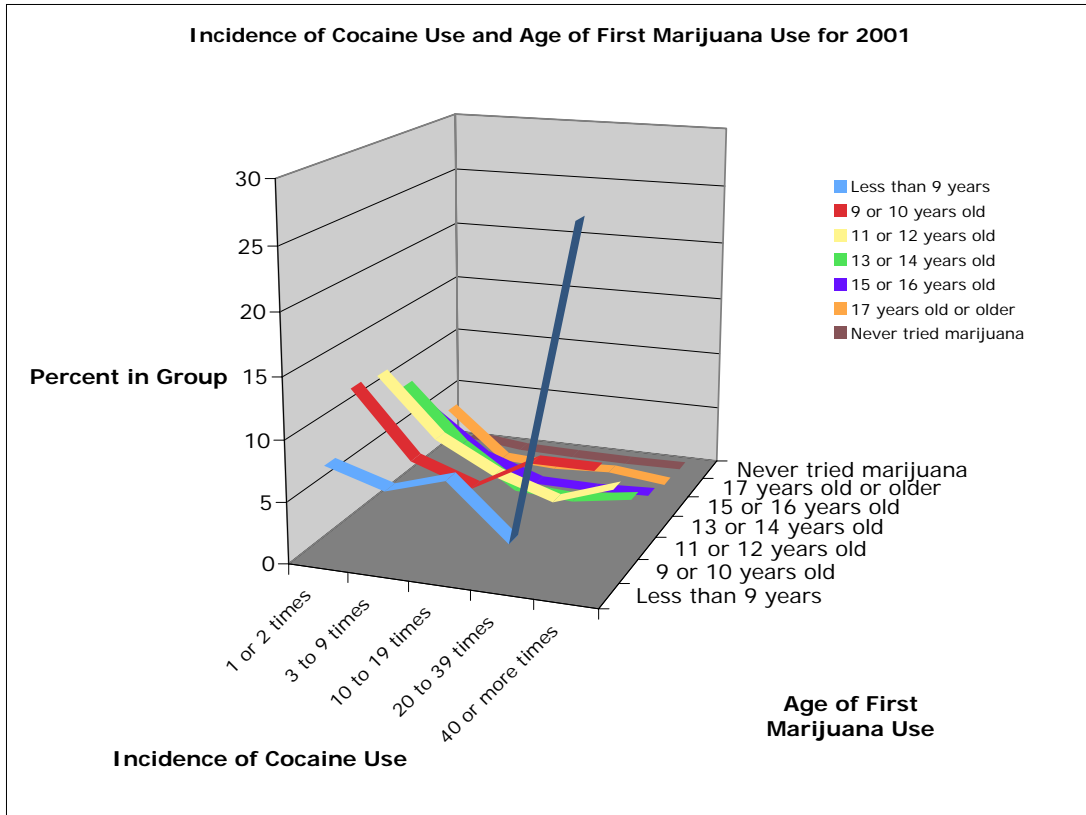


Figure 23. Plot of the percentage of people in each age of onset of marijuana use group who used cocaine the indicated number of times in 2001.

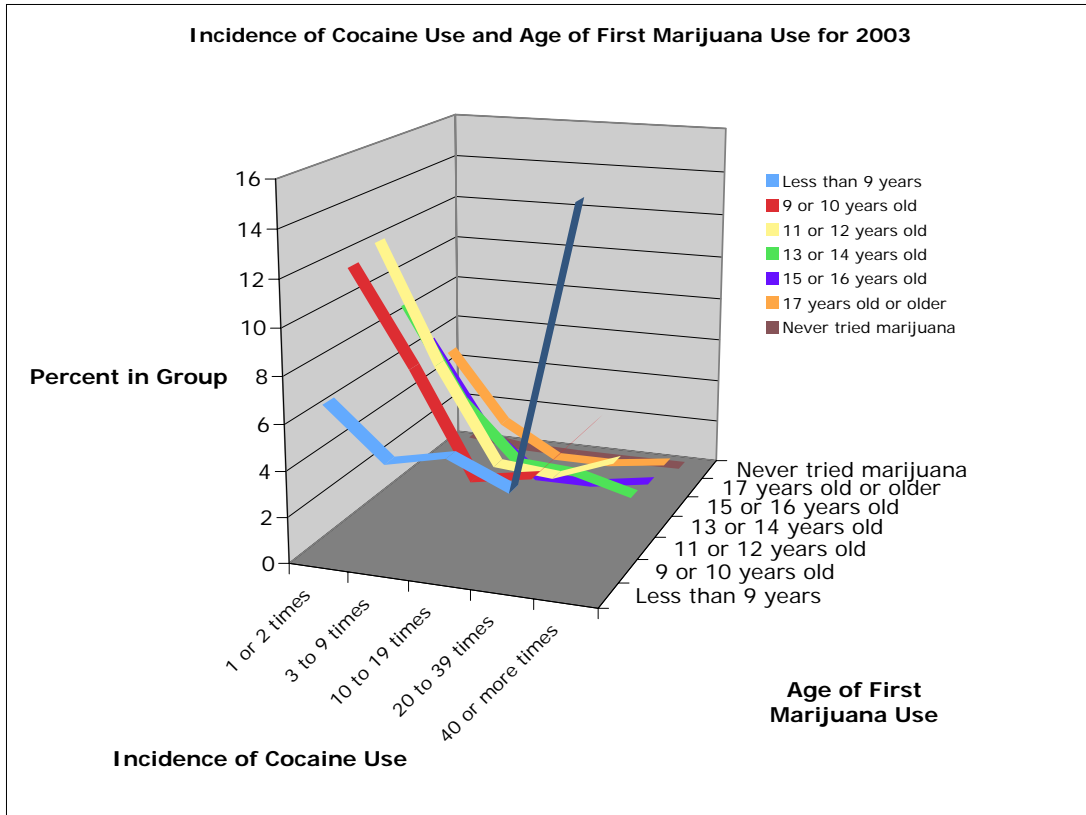


Figure 24. Plot of the percentage of people in each age of onset of marijuana use group who used cocaine the indicated number of times in 2003.

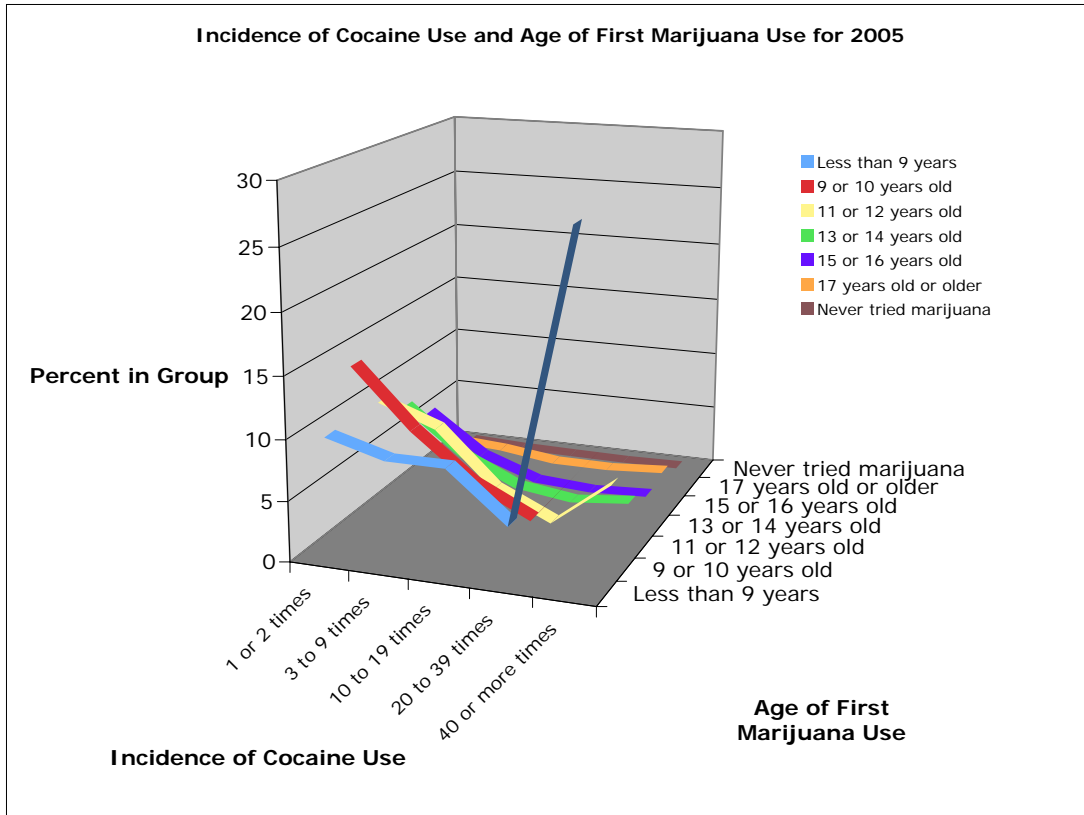


Figure 25. Plot of the percentage of people in each age of onset of marijuana use group who used cocaine the indicated number of times in 2005.

The tables and graphs showing what percentage of people had tried both gateway drugs and cocaine and what percentage of people had tried cocaine and not specific gateway drugs are shown in Figures 26 and 27. It is shown that very few people tried cocaine without trying the specified gateway drug although across all gateway drugs examined there is constantly a small percentage greater than 0 which did try cocaine without trying the gateway drug. Tobacco and marijuana appeared to be the gateway drugs that people were most likely to not try before trying cocaine with alcohol showing a comparatively low percentage of people who did not try alcohol and did try cocaine.

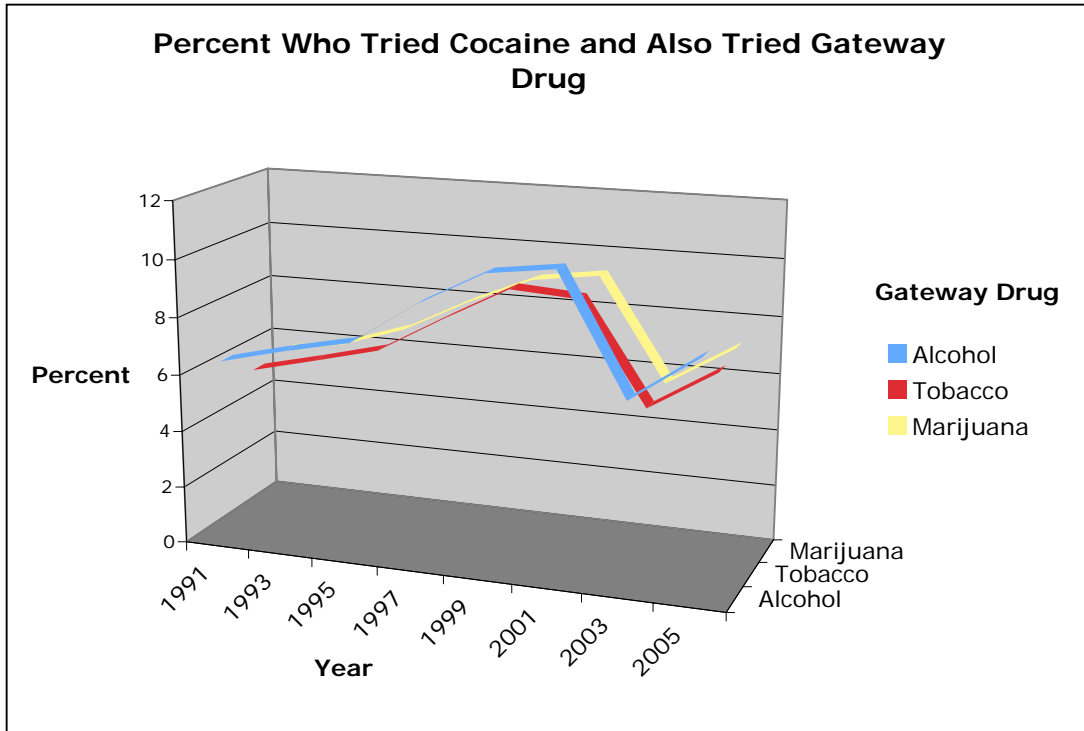


Figure 26. Plot of the percent of question respondents who indicated that they had tried both cocaine and a specific gateway drug across years. The specific gateway drug being examined is shown on the Y axis and color coded with a key on the right side of the graph.

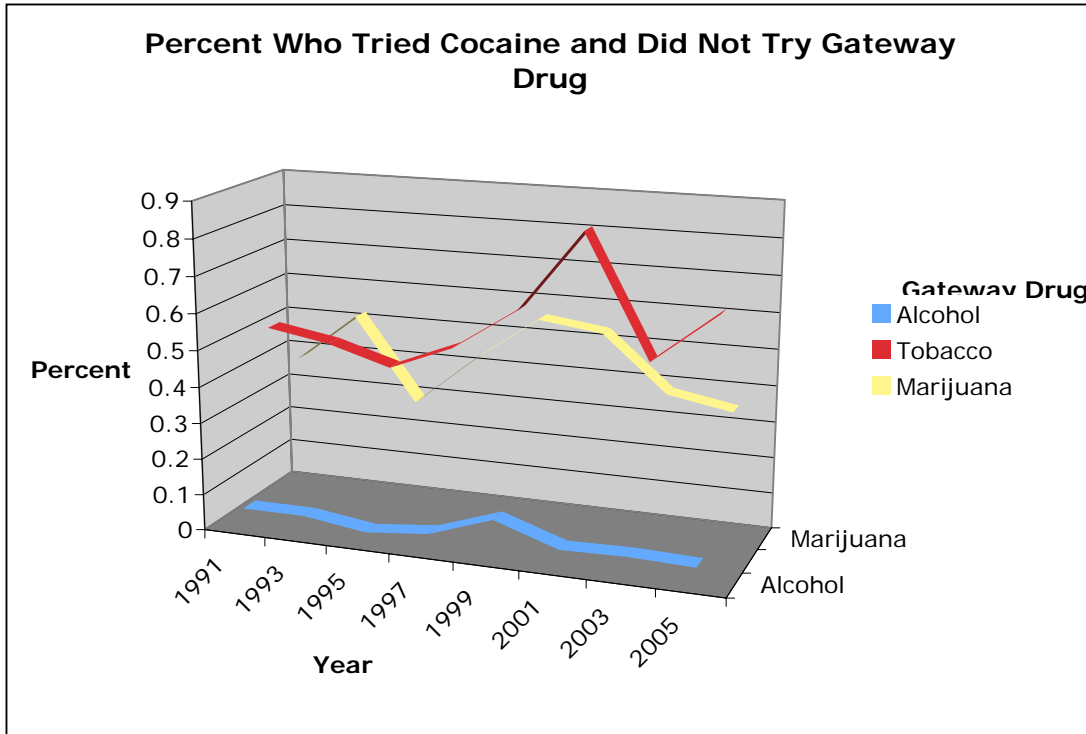


Figure 27. Plot of the percent of question respondents who indicated that had tried cocaine and not tried the specific gateway drug across years. The specific gateway drug being examined is shown on the Y axis and is color coded with a key on the right side of the graph.

The graphs examining the possibility of a risk taking personality are shown in Figures 28-32. The results of the graphing indicated a linear relationship between the risk factors studied and cocaine use. The results of the correlations are shown in Table 3. As shown in Table 3 all correlations are strong and significant indicating that the proposed linear relationships are present between percentage of people that used cocaine and the six other variables listed in Table 3.

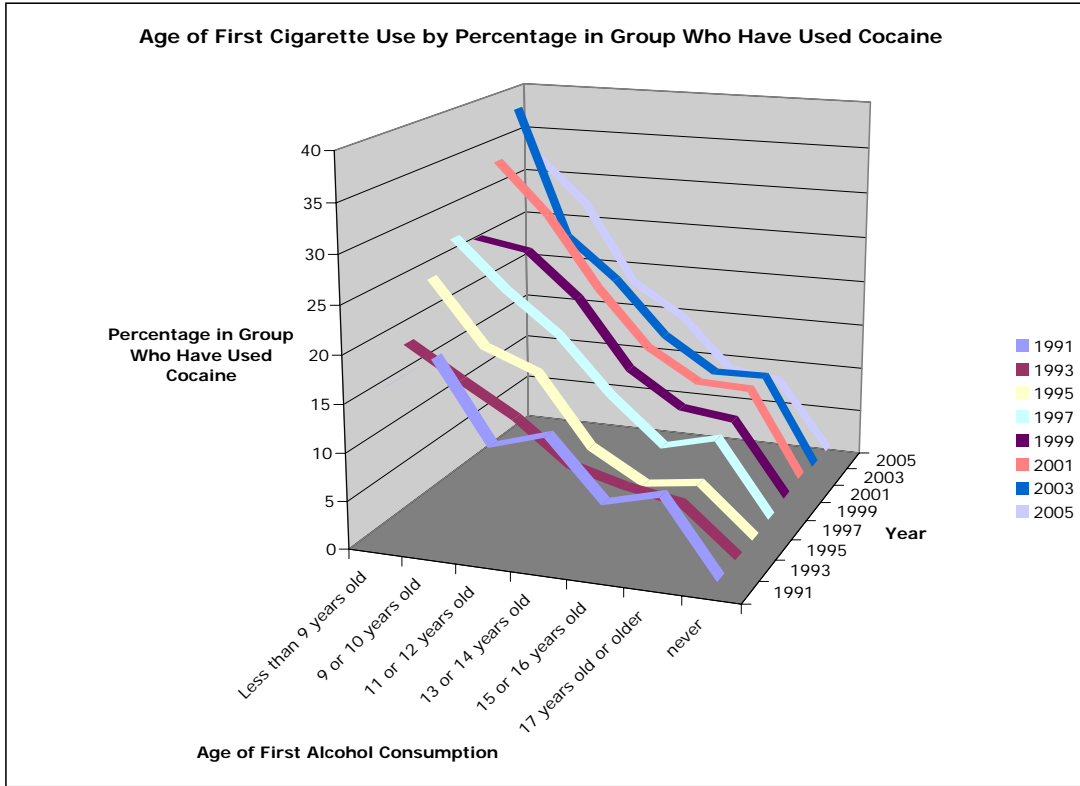


Figure 28. Plot of the percentage of people in each age of onset of cigarette use group who tried cocaine across years. Age of onset of tobacco use is indicated on the x axis, year on the y axis, and percentage of people in age of onset group who have used cocaine on the z-axis.

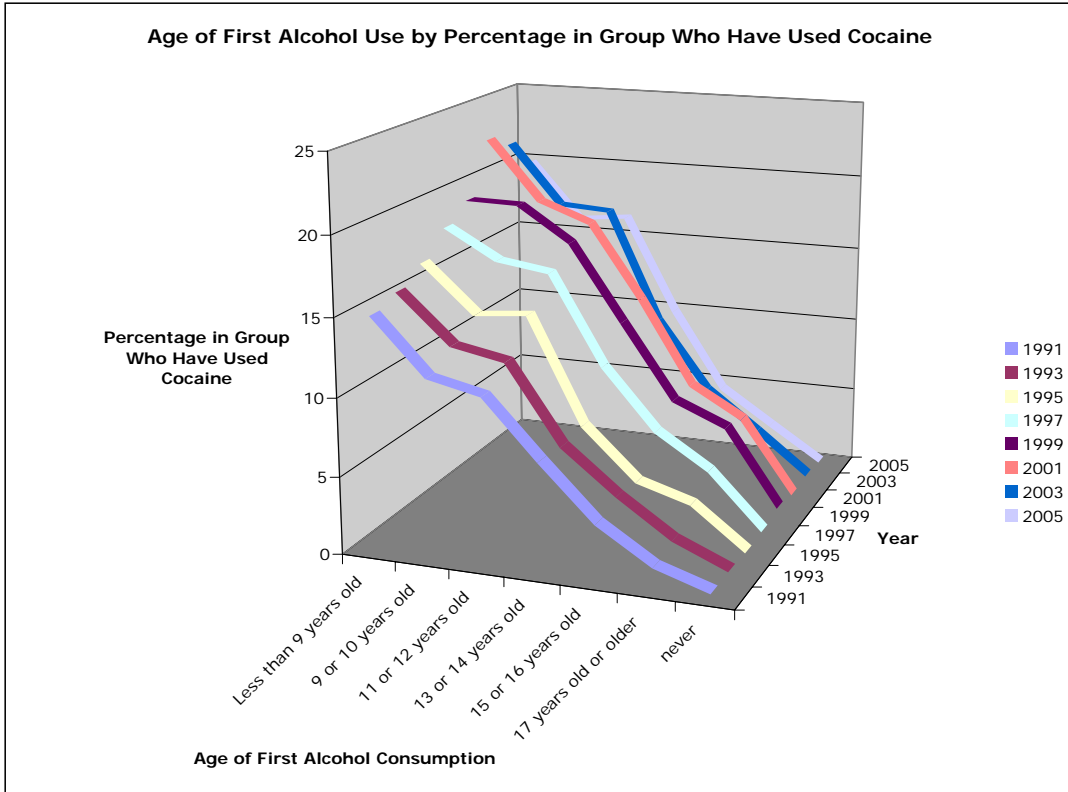


Figure 29. Plot of the percentage of people in each age of onset of alcohol use group who tried cocaine across years. Age of onset of alcohol use is indicated on the x axis, year on the y axis, and percentage of people in age of onset group who have used cocaine on the z-axis.

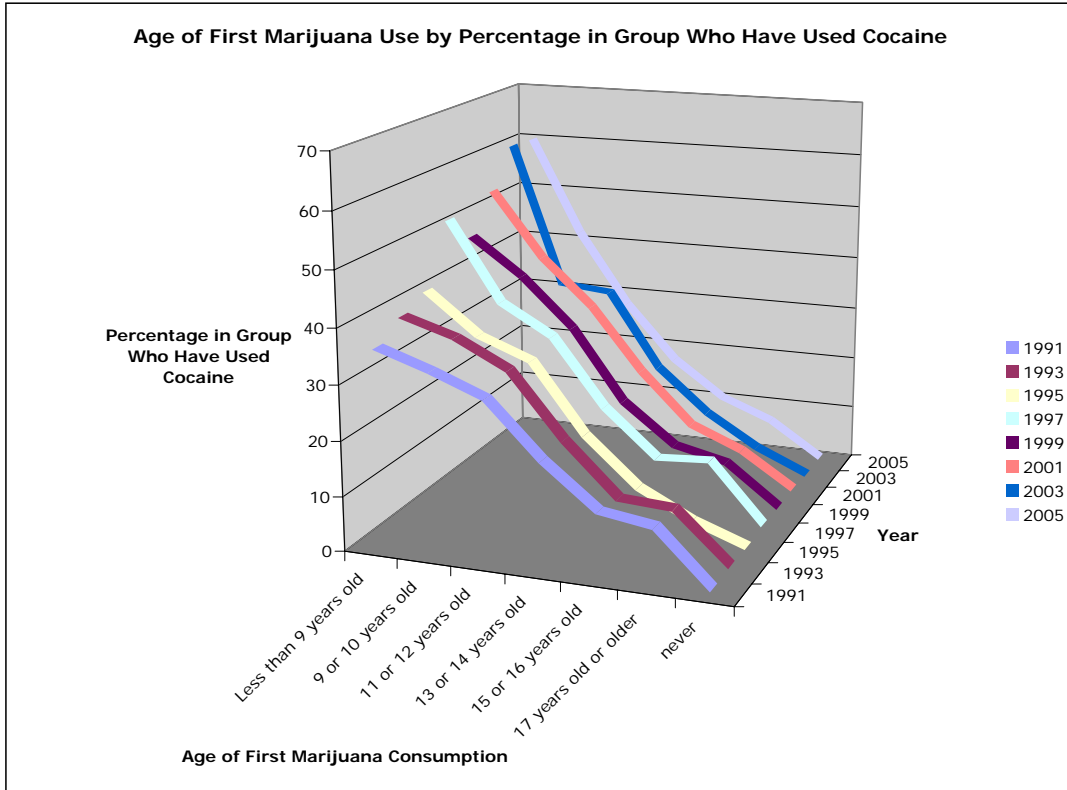


Figure 30. Plot of the percentage of people in each age of onset of marijuana use group who tried cocaine across years. Age of onset of marijuana use is indicated on the x axis, year on the y axis, and percentage of people in age of onset group who have used cocaine on the z-axis.

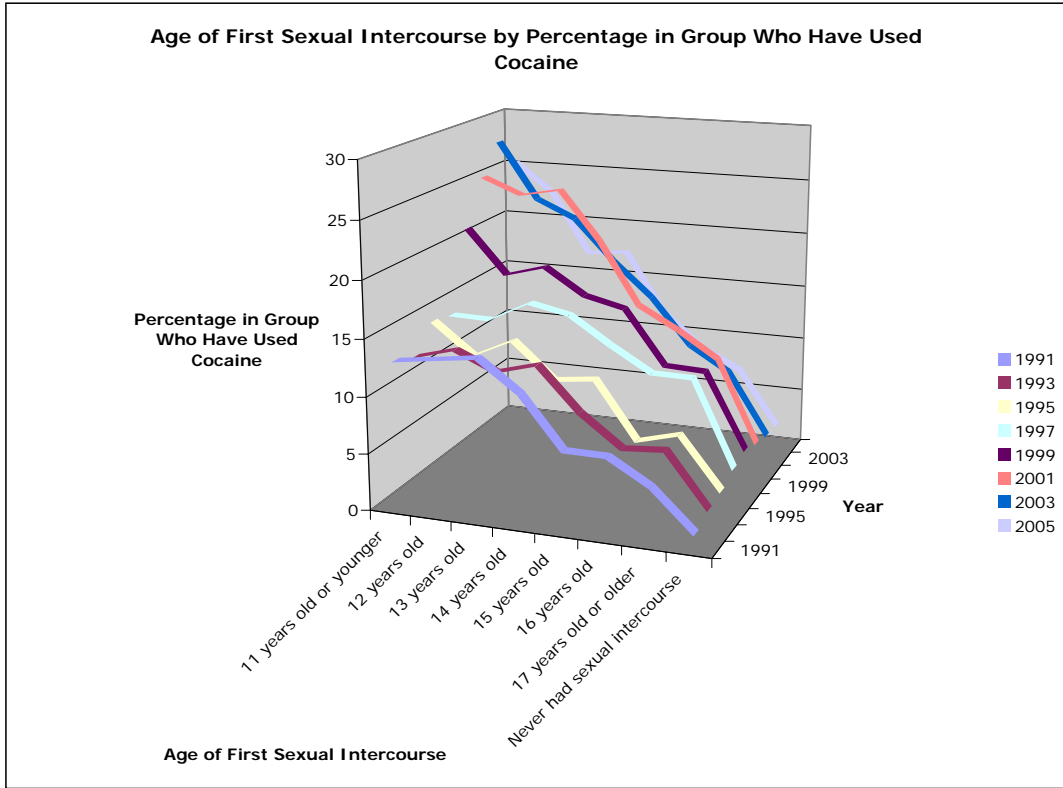


Figure 31. Plot of the percentage of people in each age of onset of sexual intercourse group who tried cocaine across years. Age of onset of sexual intercourse is indicated on the x axis, year on the y axis, and percentage of people in age of onset group who have used cocaine on the z-axis.

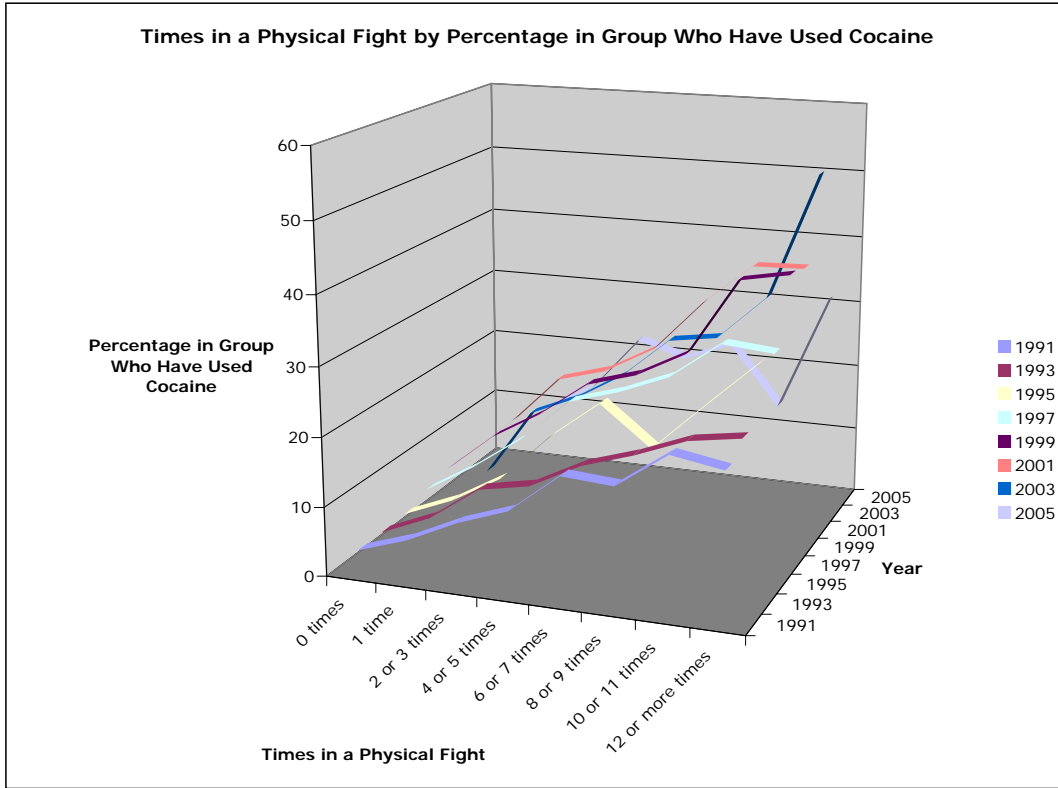


Figure 32. Plot of the percentage of people in each time in a physical fight group who tried cocaine across years. Times in a physical fight is indicated on the x axis, year on the y axis, and percentage of people in age of onset group who have used cocaine on the z-axis.

Table 3. Pearson Correlations

Correlation between Percentage of People in Group Who Used Cocaine and...	Correlation	P-Value*
Age of first Cigarette Use	-.907	.000
Age of First Alcohol Consumption	-.941	.000
Age of First Marijuana Consumption	-.963	.000
Age of First Sexual Intercourse	-.866	.000
Times in A Physical Fight	.865	.000

*P-Values less than 0.05 were considered significant.

Figures 28-32 appeared to show a possible positive linear relationship between percentage of people in each answer group who had tried cocaine and year.

In order to determine if there was a significant linear relationship partial correlations were run across years and percentage of people in group who used cocaine. The use of partial correlations allowed the researchers to examine the relationship between percentage of people in group who had used cocaine and year while controlling for age of first cigarette use, age of first alcohol consumption, age of first marijuana consumption, age of first sexual intercourse, and times in a physical fight. The results are shown in Table 4. The partial correlations demonstrate that there is a significant moderate positive correlation between year and percentage of item respondents who had tried cocaine after controlling for item response.

Because year did have a significant correlation with likelihood that the respondents tried cocaine, the researchers then wanted to make sure that the correlations between age of onset and likelihood of trying cocaine remained strong after controlling for year. Table 5 then looked at the partial correlations between percentage of people in group who had used cocaine and age of onset group. The use of partial correlations allowed the researchers to examine the relationship between percentage of people in group who had used cocaine and age of onset group while controlling for year. It was found the correlations between percentage of people in group who had tried cocaine and age of onset remained strong and significant after controlling for year.

Table 4. Partial Correlations Controlling for Age of Onset

Partial Correlation between Percentage of People in Group Who Used Cocaine and Year controlling for ...	Correlation	P-Value*
Age of first Cigarette Use	.628	.000
Age of First Alcohol Consumption	.628	.000
Age of First Marijuana Consumption	.305	.000
Age of First Sexual Intercourse	.582	.000
Times in A Physical Fight	.459	.000

*P-Values less than 0.05 were considered significant.

Table 5. Partial Correlations Controlling for Year

Partial Correlation between Percentage of People in Group Who Used Cocaine and ... controlling for year	Correlation	P-Value*
Age of first Cigarette Use	-.941	.000
Age of First Alcohol Consumption	-.963	.000
Age of First Marijuana Consumption	-.966	.000
Age of First Sexual Intercourse	-.882	.000
Times in A Physical Fight	.889	.000

*P-Values less than 0.05 were considered significant.

A two way ANOVA was performed using the UNIANOVA command in SPSS version 16.01 (version released November, 2007). The percentage of respondents in each group who had used cocaine served as the dependent variable and the level of response and year served as the independent variables. The results of the ANOVAs are shown in Table 6. Response category was shown to have a significant effect on whether or not a participant tried cocaine for all variables examined. Year was also shown to have a significant effect except when examined in conjunction with age of first marijuana consumption. The lack of significance of year in the case

of marijuana indicates that those responding to the question examining age of first marijuana use did not show significant changes in cocaine use across years

Table 6. ANOVA Results for Year and other Independent Variables

ANOVA Values For ANOVA with the independent variables Year and...	df for independent variable	F-value for independent variable	p-value	df for year	F-value for year	P-value*
Age of First Cigarette Use	6	86.322	.000	7	7.441	.000
Age of First Alcohol Consumption	6	233.894	.000	7	15.326	.000
Age of First Marijuana Consumption	6	159.131	.000	7	1.495	.195
Age of First Sexual Intercourse	7	44.944	.000	7	12.242	.000
Number of Times in a Physical Fight	7	44.597	.000	7	7.408	.000

*P-Values less than 0.05 were considered significant.

Chapter 6: Discussion

The researchers set out to determine if the data from the YRBSS would lend support to the gateway drug hypothesis or the theory that a person is generally predisposed to risk-taking behaviors. To address these concerns the researchers looked at whether there was a relationship between age of onset of drug behaviors and later increased incidence of cocaine use— the presence of a relationship indicating support of the gateway drug hypothesis. The researchers also looked at what percentage of people who tried cocaine had and had not also tried cigarettes, alcohol, or marijuana. The researchers also looked at whether there was a relationship between age of onset of risk behaviors (or in the case of physical fights incidence of risk-taking behavior) and whether or not the participant had ever tried cocaine.

The results show that there is a relationship between age of onset of drug related behavior and incidence of cocaine use. This shows a possible support for the gateway drug hypothesis. Those respondents who used cigarettes when they were nine years old or younger consistently had the highest percentage of people in their group who reported using cocaine forty or more times, an incidence rate that suggests drug abuse or dependence. Similar findings were found when looking at age of onset for alcohol and marijuana use with those who used alcohol when they were under nine years old showing an equal likelihood of trying cocaine once or twice or using it 40 or more times and those who had used marijuana before the age of nine showing a greater likelihood of using cocaine 40 or more times than trying it once or twice. Incidence of cocaine use demonstrated a parabolic trend with peaks at both using

cocaine once or twice and using cocaine forty or more times, suggesting that most people sampled either tried the drug and avoided it thereafter or likely became frequent users. In light of this trend, it is important that the both the public and federal and state governments consider not only drug prevention programs aimed at school-aged children but also carefully consider drug intervention programs for those children and teens who may already be in the throes of addiction and whose needs will not be addressed by drug education programs focused on preventing drug use. As this study has shown kids who start using gateway drugs before drug education and prevention programs are taught in school are those who are most likely to use cocaine with an incidence high enough to suggest addiction and dependence—it is important to provide services to help them turn their lives around.

The researchers found that of those who had used cocaine the vast majority had also used cigarettes, alcohol, or marijuana. Despite this vast majority there was still a constant non-zero percentage of cocaine users who had not used either cigarettes, alcohol, or marijuana. This constant non-zero percentage exposes a flaw in the gateway hypothesis which posits a strict timeline of drug behaviors going from less serious drug use—such as cigarettes, alcohol, and marijuana, to more serious drug use such as cocaine. Since some respondents did not follow the trajectory proposed by the gateway theory the researchers were lead to believe that the gateway theory was not a comprehensive theory despite the aforementioned supportive findings.

There also is a strong linear relationships between whether or not a participant had tried cocaine and age of first cigarette use, age of first alcohol consumption, age

of first marijuana use, age of first sexual intercourse, and times in a physical fight. These results suggest that it is likely that a person has a proclivity to risk taking behaviors, including drug use, rather than an inclination towards drug-specific behaviors.

The researchers also found a moderate positive correlation between year and likelihood of a participant to use cocaine when controlling for response group. This refers to the trend seen in Figure 1 where cocaine use was increasing from 1991-2001 and then dropped down from 2001 to 2003 and then showed a rise again in 2005. This finding might indicate that cocaine use is becoming more salient, even among groups of seemingly low-risk teens. This trend should be investigated further in order to prevent dangerous habits from forming among teens who are not exhibiting other warning signs of distress.

The significance of year was also confirmed through the two-way ANOVA where year was found to have a significant main effect. It is unclear why year is a significant variable and there are a few possibilities that could be examined. There is a fairly large drop off in people who tried cocaine between 2001 and 2003 and then a rise from 2003 to 2005. It is possible that the trend is indicative of cocaine falling in and out of popularity and that its popularity has a cyclical nature. It is also possible that from 2001 to 2003 the price of cocaine spiked causing economic forces to change the drug market. Another reason could be a rise in popularity of another drug such as crystal meth which temporarily replaced cocaine as the drug of choice for would-be users. Seeing how the rates of use change in the next few years and examining the above explanations would allow a more complete story of what time-related factors

influence cocaine use.

The findings expand upon the previous research discussed in the literature review. Early works such as Kandel and Yamaguchi (1993) focused mainly on drug progression ignoring the possibility of correlated risk behavior. The findings of this study expanded and supported the findings of Sutherland and Wilner (1998) whose data pointed to an overall inclination towards risky behavior. The current research has shown that early risk behavior is strongly linked to later hard drug use in a similar manner that early drug behavior is linked to later hard drug use. In addition, the relationship between year and cocaine use may reflect the results of Golub and Johnson (2001). They posited that the progression of drug use described by the gateway hypothesis is not a causal relationship but rather a reflection of contemporary societal norms in relation to drug use. As the attitude towards and market for specific drugs changes with time, so do the relationships between usages of different drugs. It is possible that the overall rise in cocaine use over the study period of 1991 to 2005 suggests a resurgence in the popularity of cocaine among drug users. The current study suggests that the gateway theory for drug use needs to be incorporated into a wider theory of the development of risk-behaviors. The results are unable to support or refute the biochemical theories of drug use that have been studied.

Chapter 7: Conclusions

The researchers found a slight curvilinear trend among incidence of cocaine use across years as well as age of onset of cigarette use, age of onset of alcohol use, and age of onset of marijuana use. With most people who have tried cocaine trying it once or twice with a decreasing tendency to try it 3-39 times and then a slight increase of people who have used cocaine forty or more times when compared with preceding groups. Subjects who reported using cigarettes when they were nine or younger showed an almost equal likelihood to have tried cocaine once or twice or to have used it forty or more times, with later years showing this group to have a higher likelihood of using cocaine 40 or more times as opposed to once or twice. Subjects who reported using alcohol when they were nine or younger showed an equal likelihood to have tried cocaine once or twice or to have used it forty or more times. Subjects who reported using marijuana when they were nine or younger showed a higher likelihood to have used cocaine 40 or more times as opposed to trying it once or twice.

People who tried cocaine were highly likely to have used marijuana, cigarettes, or alcohol as well. There was a constant non-zero percentage of people who had tried cocaine and had not used either marijuana, cigarettes, or alcohol. Comparatively speaking people were more likely to have tried cocaine and not used marijuana or cigarettes than they were to have tried cocaine and not used alcohol.

A strong linear relationship was demonstrated between age of onset of risk behavior and likelihood to have tried cocaine. The younger a person engaged in risk

behavior the more likely that person was to have tried cocaine. In the case of physical fighting the higher incidence of physicals fights indicated a higher a likelihood that the person had tried cocaine. Year showed a moderate positive relationship with likelihood that an individual had tried cocaine. Both year and age of onset showed significant main effects using Analysis of Variance.

The researchers accomplished their objectives. The results supported the hypotheses. The researchers found that the gateway theory was supported but did not provide a comprehensive explanation for the observed trends.

Chapter 8: Suggestions for Future Research

Since this study had a survey design and thus lacked the ability to manipulate independent variables or random assignment to groups it is impossible to draw causal conclusions. Instead, the findings of this study should be viewed as a starting point for more targeted research. Assuming that the researchers' findings are correct and that some individuals have an increased inclination to taking more risks, the cause of an affinity for risk-taking is unknown. There are a number of possibilities including an inability to think about future consequences, a feeling of invincibility, a lack of concern for personal safety or the consequences their behavior has on others, the effects of trauma (physical or psychological), as well as possible genetic factors. Examining why some people gravitate towards risk while others choose safer routes could help spawn the creation of effective interventions for young people who are prone to voluntarily putting themselves in danger.

Another possible line of research is looking at targeted interventions for people prone to risk-taking. It might be possible to substitute more socially acceptable forms of risk-taking such as adrenaline sports like water rafting instead of drug behaviors. Studies could look at whether exposing at-risk youth to these types of opportunities prevents them from experimenting with drugs.

It is also important to look at whether those respondents who indicated that they used cocaine forty or more times are indeed addicted to or abusing drugs. Whether drug education programs in the schools have an effect on incidence of people who progress from drug experimentation to drug addiction and drug abuse

should be investigated. It would also be necessary to design an experimental study where drug education programs focused on prevention and drug education programs focused on both prevention and intervention were compared based on their longitudinal effects on drug behavior.

The ideal follow up to this study would be a longitudinal study tracking risk behaviors from early childhood through adulthood. Measures covering propensity towards risk taking, actual risk behaviors, personality type, family functioning, genetic predisposition, and traumas would be helpful in determining the best predictors of risk taking. Once the predictors and trajectory of risk-taking are well understood effective interventions can be designed to help keep young people safe.

Appendix A- Questions Occurring Across All Years

1. How old were you when you have your first drink of alcohol other than a few sips?
2. During the past 30 days, on how many days did you have at least one drink of alcohol?
3. During the past 30 days, on how many days did you have 5 or more drinks of alcohol in a row, that is within a couple of hours?
4. How old are you?
5. In what grade are you?
6. Race
7. During the past 12 months, did you ever seriously consider attempting suicide?
8. During the past 12 months did you make a plan about how you would attempt suicide?
9. During the past 12 months how many time did you actually attempt suicide?
10. If you attempted suicide during the past 12 months, did any attempt result in an injury, poisoning, or overdose that had to be treated by a doctor or nurse?
11. How old were you when you tried marijuana for the first time?
12. During your life how many times have you used marijuana?
13. During the past 30 days, how many times did you use marijuana?
14. During your life, how many times have you used any form of cocaine including powder, crack, or freebase?
15. During your life, how many times have you taken steroid pills or shots without a doctor's prescription?
16. During an average physical education (PE) class, how many minutes do you spend actually exercising or playing sports?
17. In an average week when you are in school, on how many days do you go to physical education (PE) classes?
18. How old were you when you had sexual intercourse for the first time?
19. During your life, with how many people have you had sexual intercourse?
20. During the past 3 months, with how many people did you have sexual intercourse?
21. Did you drink alcohol or use drugs before you had sexual intercourse the last time?
22. The last time you had sexual intercourse, did you or your partner use a condom?
23. The last time you had sexual intercourse, what one method did you or your partner use to prevent pregnancy?
24. Have you even taught about AIDS/HIV infection in school?
25. Have you ever tried cigarette smoking, even one or two puffs?
26. Have you ever smoked cigarettes regularly, that is, at least one cigarette every day for 30 days?
27. During the past 30 days, on how many days did you smoke cigarettes?

28. During the past 30 days, on the days you smoked, how many cigarettes did you smoke per day?
29. How old were you when you smoked a whole cigarette for the first time
30. How often do you wear a seat belt when riding in a car driven by someone else
31. When you rode a bicycle during the past 12 months, how often did you wear a helmet?
32. During the past 30 days how many times did you ride in a car or other vehicle being driven by someone who had been drinking alcohol
33. During the past 30 days how many times did you drive a car or other vehicle when you had been drinking alcohol
34. During the past 12 months, how many times were you in a physical fight?
35. During the past 12 months, how many times were you in a physical fight in which you were injured and had to be treated by a doctor or nurse?
36. During the past 30 days, on how many days did you carry a weapon such as a gun, knife, or club?
37. What is your sex?

Appendix B – Glossary of Terms

Controlling for... - manipulation of data in order to mitigate the effects of antecedent, intervening, and spurious variables.

DSM – Diagnostic and Statistical Manual of Mental Disorders; current version is IV; suffix “-R” indicates a revised version.

Hard Drug – psychoactive drugs that are especially potent, potentially lethal, and may have addictive properties. Common examples include: cocaine, heroin, methamphetamines, etc.

Longitudinal Study – observational study that includes repeated examinations of a constant set of items over an extended period of time.

Odds Ratio – descriptive statistic concerning the relationship between two binary values. For example, the statement “the odds of a teen not smoking marijuana are 2:1” indicates that in a sample of 3, 2 teens will have not smoked marijuana and 1 will have smoked marijuana.

Psychoactive Drug – substance foreign to the body that induces a change in brain function, including alterations in behavior and mood.

Risk Behavior – behavior that increases the likelihood for personal injury, sexually transmitted infections, and other avertable health conditions.

Risk-Taking Personality – an innate proclivity of an individual to engage in risk behaviors at a higher frequency than other individuals

Socialization – the process by which an individual becomes acclimated to and learns to function in his/her surrounding culture.

Soft Drug – psychoactive drugs that are less dangerous and have less addictive properties than hard drugs. Common examples include: marijuana, Salvia divinorum, peyote, etc.

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