

## RESPONSE RELIABILITY AND THE STUDY OF ADOLESCENT SUBSTANCE USE PROGRESSION

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*Studies of adolescent substance use progression typically infer a sequence of initiation from self-reported ages at first use of alcohol, tobacco, marijuana, and hard drugs. This paper examines the reliability of this procedure for a sample of 892 New Jersey youths interviewed on two occasions separated by three years. Individual responses on the second occasion differed substantially from those provided on the first. However, the inferred sequences were consistent as long as 1) first use of alcohol and/or tobacco was considered a single stage, and 2) cases in which individuals initiated the use of two substances in the same year were considered as ambiguous regarding order. The sequences reported were also consistent with the gateway theory that suggests alcohol/tobacco precedes any possible use of marijuana and hard drugs.*

### INTRODUCTION

An extensive literature review has examined *substance use progression*, the sequence of substances an individual initiates, and its correlates. Most of this literature has explored substance use progression in the mainstream community (Andrews et al. 1991; Blaze-Temple and Lo 1992; Brook et al. 1982; Donovan and Jessor 1983; Elliott et al. 1989; Fleming et al. 1989; Hays and Ellickson 1991; Kandel 1978; Kandel et al. 1992; Welte and Barnes 1985). These studies consistently suggest that mainstream youths typically followed a pathway starting with the use of alcohol and/or tobacco in early adolescence, possibly followed by use of marijuana and then hard drugs, a sequence referred to as the *gateway theory*. Individuals who used substances at one stage did not always progress to

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use of substances at the next. However, individuals who did not use substances at one stage rarely initiated the use of substances associated with later stages.

Several recent studies of explicitly non-mainstream samples drawn from inner-city New York found that many individuals who had become hard drug users started their progression with marijuana instead of the more usual alcohol or tobacco (Golub and Johnson 1994; Mackesy-Amity, Fendrich and Goldstein 1997). These findings are consistent with detailed psychological and anthropological analyses that suggest the substances an individual uses, frequency, and reasons for use are often strongly influenced by the prevailing substance use culture and an individual's place within it (Schulenberg, Maggs, and Hurrelmann 1997). These cultures can vary across locations and over time. Additionally, several substance use subcultures may simultaneously prevail in a single location at the same time.

Most of the studies referenced above reconstructed individual substance use sequences from their ages at first use for various substances as self-reported retrospectively. These measures are prone to a variety of recall and reporting errors that could potentially affect the validity of inferences about the sequences followed. This study examines the reliability (an important component of validity) of age at first use data by comparing self-reports provided by a group of youths on two separate occasions. An individual who was telling the truth on both occasions would have provided the same answer at each. However, there are a variety of possible scenarios in which an individual would have provided reliable but incorrect information. Some youths might have constructed stable though inaccurate memories of the events involved. Others might have simply remembered the inaccurate response provided at the first interview. In this sense, reliability is a necessary but not a sufficient indicator of a valid response.

In a summary of the literature, Eisenhower, Mathiowetz and Morganstein (1991) report that the accuracy of survey responses can be adversely affected by a variety of psychological and communication factors. One possibility is that the clarity with which individuals remember their first use of a substance and their age at the time may simply fade as the years pass. Alternatively, unreliability may increase with time because personal memories rarely contain information about absolute time (Brewer 1988). Indeed, several studies suggest that individuals often inconsistently report whether they had even used a substance (Bailey, Flewelling and Rachal 1992; Fendrich and Vaughn 1994; Johnston and O'Malley 1997).

Among those that do disclose their use, quite commonly they underestimate the time since their first use, a phenomenon known as *forward telescoping*. In this regard, a panel of individuals interviewed on two occasions several years apart will typically, on average, report having initiated substance use at a later age at reinterview. Numerous studies have found evidence of forward telescoping in response to a variety of questions (Eisenhower, Mathiowetz and Morganstein 1991). Indeed, Johnson, Gerstein and Rasinski (1997a) found evidence of such

telescoping in response to questions of age at first use of various substances in the National Household Survey on Drug Abuse.

In general, forward telescoping is often more pronounced for particularly important events. Perhaps the clarity of recall suggests to the individual that the event must have occurred recently. Forward telescoping can also result from a continuing redefinition of what an individual believes constitutes first use, even if the question is stated the same. Younger children might count a sip or two of a parent's drink as their first use of alcohol; older individuals might remember the first time they bought liquor or got drunk with friends. Alternatively, forward telescoping can result from respondents deliberately increasing their age at first use across interviews due to an increased desire to present more socially-acceptable answers.

In a previous study with the same data set analyzed here, Labouvie, Bates and Pandina (1997) found these youths rarely reported the same ages at first use on both occasions and that forward telescoping of their responses had prevailed. This paper examines the nature of the inaccuracy and bias in reported age at first use in greater detail and explores the extent to which these inconsistencies affect the implied sequence of substances used.

Many scholars, government office holders, providers of substance-abuse treatment, and prevention practitioners place great importance on the sequence of substances initiated. It was hypothesized that individuals would similarly attach great importance to their sequence of substances used. In this regard, it was expected that each individual's implied sequence of substances used would be consistent, even if her or his reported ages at first use changed over time. Indeed, it was postulated that individuals might even organize their memories of ages at first substance use according to substance use progression. For example, an individual might remember starting marijuana use about two years after starting use of alcohol. Based on this salient memory, the individual might indicate having first used alcohol at age 11 and marijuana at age 13 at Time 1. At Time 2, the individual might be unclear as to the exact date at first use of alcohol and report having initiated use at age 14. Remembering the general sequence of substance use initiation, the individual might then report having started use of marijuana at age 16. Thus, it was further hypothesized that the changes in reported ages at use of each substance will be highly correlated.

#### **METHODS**

This study examined data from the Rutgers Health and Human Development Project, a longitudinal study of development in adolescence and young adulthood (for a complete description of the project see Horwitz and White, 1987). During 1979-1981, eligible adolescents were recruited through a random sampling of telephone numbers covering all but the five counties of New Jersey most distant from the test site. Successive rounds of telephone calls were carried out to fill specific quotas of 200-225 males and females aged 12, 15, and 18. Only data

obtained from 12 and 15 year olds were used in this analysis. Respondents were predominantly white (89 percent), although a few were black (8 percent). Following the telephone contact, field staff briefly interviewed interested participants and their parents in their homes. Subsequently, adolescents came to the research center for a full day of testing on four occasions spanning a 13-year period.

At the first site visit, respondents provided the substance use information designated as the first interview in this study [Time 1]. Nearly all of these individuals (97 percent) agreed to participate in the second interview [Time 2] conducted three years later at ages 15 and 18, respectively. A total of 30 individuals (3 percent) dropped out after Time 1. A sample of 437 individuals age 12 at Time 1 and 455 individuals age 15 provided information at both occasions. Throughout this paper, those individuals who were age 12 at Time 1 are referred to as the *younger cohort*, and those who were age 15 as the *older cohort*.

At each interview, efforts were made to establish rapport, and the confidentiality of findings were stressed in order to obtain the most honest responses. To further assure confidentiality, no one other than the interviewer and respondent were in the room at the time of questioning, and individuals marked their responses directly in the questionnaire. The interviewers remained available to help if respondents had trouble reading; in which case, the interviewer read the questions to them and marked their oral responses in their questionnaire. Respondents were not given any special instructions that might have helped direct their attention towards the events surrounding first use of each substance and the context in which each occurred. Such probing is often used in an attempt to enhance a respondent's ability to accurately recall when an event occurred (Eisenhower, Mathiowetz and Morganstein 1991).

At Time 1, respondents were explicitly asked the age at which they had a first drink of beer, wine, or liquor ("more than a few sips of someone else's drink"); the age at which they first smoked a cigarette ("more than a few puffs"); and the age at first use of each of various illegal drugs. The age at first use of alcohol was identified as the earliest use of beer, wine, or liquor. For this study, the age at first use of hard drugs was defined as the first use (if any) of either cocaine (as either a powder or as crack), a drug with a particularly strong pharmacological effect that a substantial proportion of youths had tried during the late 1970s and 1980s (Johnston, O'Malley and Bachman 1998), or heroin, a drug of much concern whose use had been popular during the 1960s and early 1970s (Boyle and Brunswick 1980; Clayton and Voss 1981; Golub and Johnson 1999; Hunt and Chambers 1976).

At Time 2, individuals were asked whether they had tried or used each substance "during the last three years." Those who answered yes on either occasion were asked, "About how old were you the first time you ever tried...?" This sequence of questions did not fully anticipate the reliability analysis

presented in this paper. Individuals who had not used a substance between interviews were not asked their age at first use. Thus, this paper examines the self reports for individuals who reported use by Time 1 *and* reported having used the substance at least once during the three years in between interviews. This may have biased the analysis in either direction. It is conceivable that the persistent users included in this analysis may have had clearer memories of their first use than those who had stopped using. On the other hand, stopping use may have involved a conscious effort. As a result, those individuals might be the ones who had clearer memories of their age at first use.

Individuals affected by this restriction would have provided a report of use at Time 1 but not Time 2. However, there are several other possible reasons why individuals might not have reported use at Time 2: 1) the respondent never used the substance, and the reported use at Time 1 was inaccurate; 2) the respondent did not remember any use at Time 2; and 3) the respondent decided against disclosing any use at Time 2. Thus, non-reporting at Time 2 provides an upper bound, and potentially a very loose upper bound, on the number of cases lost due to restricting questioning of age at first use to individuals who reported any use in the last three years. Of the 587 youths who reported lifetime use of alcohol at Time 1, relatively few (66 or 11 percent) did not report use at Time 2. Similarly, relatively few (14 percent, or 32 out of 232) of the youths who reported marijuana use at Time 1 failed to report use at Time 2. The rates were much higher for tobacco (27 percent, or 91 of 335) and for hard drugs (36 percent, or 5 of 14).

## RESULTS

This section first examines the consistency of reported age at first use of each substance and then how this inconsistency affected the implied sequences of substances used.

### *CONSISTENCY OF REPORTED AGE AT FIRST USE*

Table 1 provides several measures for the consistency of reported ages at first use for each substance. In preparing this table, the consistency for each individual's responses was calculated as the difference,  $\Delta$ , across interviews in the reported age at first use. The average of these differences,  $\mu(\Delta)$ , identifies the general tendency of respondents to increase (indicated by a positive value) or decrease (a negative value) their reported age at first use; it is thus a measure of forward telescoping. This computation provides the same result as taking the difference between the average age reported at Time 1 and the average age reported at Time 2. The standard deviation of individual differences,  $\sigma(\Delta)$ , identifies the extent to which individual responses tended to vary across interviews; it is an indicator of reliability. The correlation coefficient,  $\rho$ , identifies whether individuals were generally consistent across interviews as to their relative ranks as earlier or later initiators of a substance; it is another indicator of reliability.

**TABLE 1**  
**VARIATION IN REPORTED AGE AT FIRST USE ACROSS INTERVIEWS**  
**(N=437 AGE 12 AND 455 AGE 15 AT TIME 1)**

| Substance            | Age at<br>Time 1 | N <sup>b</sup> | Age at first use reported <sup>a</sup> |        | $\mu(\Delta)^c$ | $\sigma(\Delta)$ | $\rho$ |
|----------------------|------------------|----------------|----------------------------------------|--------|-----------------|------------------|--------|
|                      |                  |                | Time 1                                 | Time 2 |                 |                  |        |
| Alcohol              | 12               | 151            | 8.1                                    | 9.2    | 1.2**           | 3.0              | .32**  |
|                      | 15               | 370            | 9.7                                    | 11.0   | 1.4**           | 3.4              | .41**  |
| Tobacco              | 12               | 47             | 9.7                                    | 10.4   | 0.7             | 2.3              | .23    |
|                      | 15               | 197            | 11.3                                   | 12.1   | 0.8**           | 2.2              | .53**  |
| Alc/Tob <sup>d</sup> | 12               | 170            | 8.2                                    | 9.2    | 1.0**           | 3.0              | .31**  |
|                      | 15               | 388            | 9.4                                    | 10.8   | 1.4**           | 3.2              | .44**  |
| Marijuana            | 12               | 11             | 10.9                                   | 11.2   | 0.3             | 0.9              | .82**  |
|                      | 15               | 189            | 13.0                                   | 13.6   | 0.6**           | 1.6              | .52**  |
| Hard Drugs           | 12               | 0              | —                                      | —      | —               | —                | —      |
|                      | 15               | 9              | 14.1                                   | 15.3   | 1.2**           | 0.7              | .76*   |

<sup>a</sup>Age at first use for those individuals who reported an age at both interviews.

<sup>b</sup>Number of individuals who reported age at first use at both interviews.

<sup>c</sup>Increase in age at first use reported at Time 2 for those who reported an age at both interviews.

<sup>d</sup>Earliest use of alcohol or tobacco, whichever came first.

\*Significantly different from zero in a two-tailed test at the  $\alpha=.05$  level.

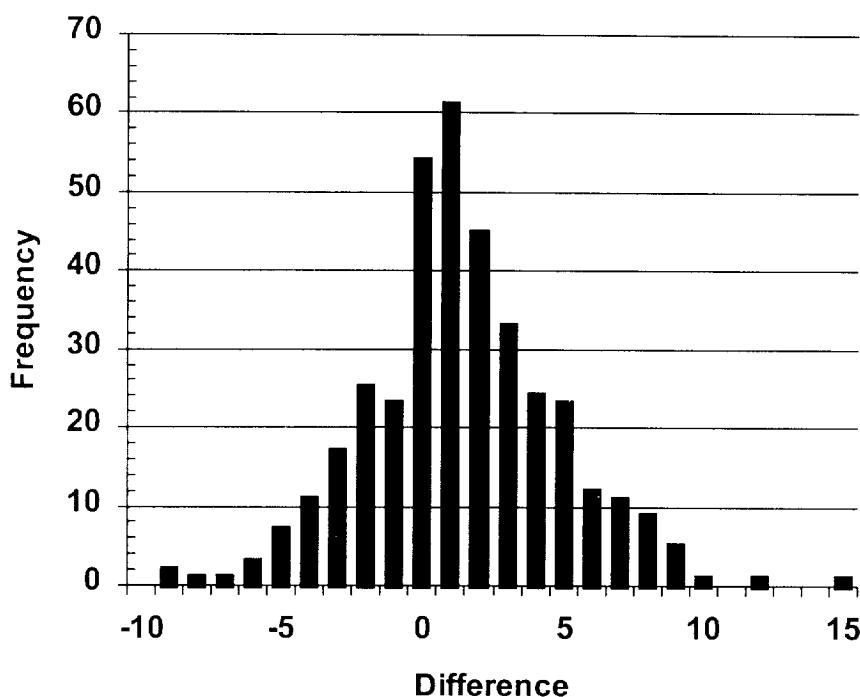
\*\*Significantly different from zero in a two-tailed test at the  $\alpha=.01$  level.

A histogram of the differences in reported age at first use across interviews was also constructed for each substance and each cohort. A visual inspection of these graphs helped suggest the types of biases prevailing. The general outline of each revealed a common unimodal pattern. Figure 1 shows the pattern for differences in reported age at first use of alcohol for the older cohort. This unimodal pattern indicates that the observed increase in age at first use, on average, was not the result of a few individuals who had deliberately and consistently reported having started at a substantially older age. Indeed, at reinterview nearly as many individuals reported having started at a younger than at an older age. These data suggested that individuals were not quite certain of their exact age at first use as opposed to their having made any deliberate attempt to alter their responses.

The magnitude of overall unreliability of responses was quite noteworthy. With regard to alcohol, a change in the reported age at first use of five years, either way, was not uncommon. Indeed, the standard deviation of differences,  $\sigma(\Delta)$ , was 3.4 years. Moreover, this inconsistency in reported age at first use led to inconsistency in individual ranking as indicated by a relatively small correlation coefficient,  $\rho=.41$ . (As a comparison, an index is conventionally judged as highly reliable if it has a correlation of 0.8 or even 0.9.) A comparison of the responses provided by the younger cohort across interviews revealed a

similar amount of unreliability ( $\sigma=3.0$ ,  $\rho=.32$ ). Somewhat smaller deviations in age at first use were provided in response to questions about age at first use of tobacco ( $\sigma=2.3$  and  $2.2$  years for the younger and older cohorts, respectively), although the correlations were not much better ( $\rho=.23$  and  $.52$ ). The responses regarding age at first use of marijuana were substantially more reliable ( $\sigma=0.9$  and  $1.6$  years,  $\rho=.82$  and  $.52$ ) as were responses regarding age at first hard drug use ( $\sigma=0.7$ ,  $\rho=.76$  for the older cohort).

**FIGURE 1**  
**HISTOGRAM OF DIFFERENCES IN AGE AT FIRST USE OF ALCOHOL ACROSS INTERVIEWS**  
**(TIME 2 - TIME 1) FOR INDIVIDUALS WHO REPORTED USE**  
**AT BOTH AGES 15 AND 18 (N=370)**



The average differences in self-reported age at first use across interviews,  $\mu(\Delta)$ , indicated a general tendency towards forward telescoping of responses that prevailed throughout adolescence from ages 12 to 15 and from 15 to 18. However, this was not necessarily the case on an individual basis, as many respondents reported earlier ages at first use upon reinterview as indicated in Figure 1. Although substantial, the amount of forward telescoping measured as  $\mu(\Delta)$  was considerably smaller than the general unreliability of responses,  $\sigma(\Delta)$ .

Individual reports of age at first alcohol use increased 1.2 years, on average, from ages twelve to fifteen, and 1.4 years from ages fifteen to eighteen. Less forward telescoping was observed with regard to reported age at first use of tobacco for either cohort. As with alcohol, the standard deviation of reported age at first use of tobacco and marijuana was about three times as large as the average difference for both cohorts. The average increase of 0.7 years reported by the younger cohort was not statistically significant due to the limited number of individuals (47) who reported tobacco use at both interviews. A similar average increase (0.8 years) for the older cohort was significant. The average increase in reported age at first use of marijuana (0.3 years) for the younger cohort was not statistically significant due to the small sample size (11). The average increase for the older cohort of 0.6 years was statistically significant. A significant increase of 1.2 years in the reported age at first use of hard drugs for the older cohort was statistically significant but was not particularly reliable due to the small sample size (9).

**TABLE 2**  
**COVARIATES OF FORWARD TELESCOPING**

| Covariates                                           | <u>OLS regression model of difference in reported</u><br><u>age at first use (Time 2 - Time 1)</u> |         |         |           |
|------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------|---------|-----------|
|                                                      | Alcohol                                                                                            | Tobacco | Alc/Tob | Marijuana |
| Female                                               | 0.2                                                                                                | 0.4     | 0.1     | 0.5*      |
| Age 15 at Time 1                                     | 1.2**                                                                                              | 0.8*    | 1.1**   | 0.8       |
| Age at first use<br>reported at Time 1: <sup>a</sup> | **b                                                                                                | **b     | **b     | b         |
| 0-7                                                  | 2.5                                                                                                | 2.0     | 2.3     | 1.2       |
| 8-9                                                  | 1.0                                                                                                | 0.5     | 0.9     | 0.1       |
| 10-11                                                | -0.4                                                                                               | 0.1     | -0.2    | 0.2       |
| 12-13                                                | -1.5                                                                                               | -1.0    | -1.3    | -0.4      |
| 14-15                                                | -2.5                                                                                               | -0.7    | -1.9    | -0.9      |
| R <sup>2</sup>                                       | 32%                                                                                                | 21%     | 30%     | 18%       |
| n                                                    | 521                                                                                                | 244     | 558     | 200       |

<sup>a</sup>No constant term was included in the model. This allowed for the inclusion of a dummy variable for each reported age at Time 1, instead of designating one response as the comparison group.

\*Result of F-test (4 d.o.f.) for inclusion of all age categories, simultaneously.

\*Significantly different from zero in a two-tailed test at the  $\alpha=.05$  level.

\*\*Significantly different from zero in a two-tailed test at the  $\alpha=.01$  level.

The variation in reported age at first use was not particularly systematic. Table 2 presents results from Ordinary Least-Squares [OLS] regression analyses of the difference in reported age at first substance use ( $\Delta$ ) of alcohol, tobacco, alcohol/tobacco, and marijuana. (Hard drugs were excluded from these analyses due to a particularly small sample size.) Overall, gender, birth cohort, and age at

first use reported at Time 1 accounted for only a modest proportion of the variation ( $R^2$  ranged from 18 percent to 32 percent). There was much systematic variation with age at first use reported at Time 1; individuals who reported particularly young ages of first use at Time 1 were more likely to increase their reported age at Time 2; those who had reported high ages of first use at Time 1 were more likely to decrease their reported age at Time 2. This was not surprising because there were both lower and upper limits on valid responses; i.e., individuals who reported an age at first use of 14-15 at Time 1 were limited as to how far they could possibly increase their response at Time 2. After controlling for this effect, the models indicated that the older cohort tended to increase their reported ages at first use for each substance by about a year (0.8 to 1.2 years) more than did the younger cohort. Girls were no more likely to forward telescope their responses than were boys for each substance except marijuana; they tended to increase their initial age at first use by half-a-year more than did boys.

Moreover, the variations over time in reported ages at first use were not related across substances. Table 3 presents a correlation matrix for the differences in age at first use of each substance across interviews,  $\Delta$ . Overall, the correlations were small (ranging from -0.05 to 0.28). Moreover, only one correlation coefficient was statistically significant, and then only for the older cohort and only at the  $\alpha=.05$  level. Individuals who reported an increase in age at first use of tobacco were somewhat more likely to have reported a corresponding increase in age at first use of marijuana ( $p=.21$ ). These correlation coefficients suggest that changes in reported age at first use of each substance were random and that they did not systematically preserve the timing of the sequence of substances an individual used as had been initially hypothesized.

**TABLE 3**  
CORRELATION OF DIFFERENCES IN AGE AT FIRST USE ACROSS INTERVIEWS BY SUBSTANCE

| Pearson's correlation of difference in age at first use across interviews |         |         |           |            |
|---------------------------------------------------------------------------|---------|---------|-----------|------------|
|                                                                           | Alcohol | Tobacco | Marijuana | Hard Drugs |
| <u>Age 12 at Time 1</u>                                                   |         |         |           |            |
| Alcohol                                                                   |         | .28     | .20       |            |
| Tobacco                                                                   |         |         | .15       |            |
| <u>Age 15 at Time 1</u>                                                   |         |         |           |            |
| Alcohol                                                                   |         | .11     | .13       | -.05       |
| Tobacco                                                                   |         |         | .21*      | .26        |
| Marijuana                                                                 |         |         |           | -.02       |

\*Significant at the  $\alpha=.05$  level of significance.

\*\*Significant at the  $\alpha=.01$  level of significance.

#### CONSISTENCY OF REPORTED SEQUENCE OF SUBSTANCES USED

Table 4 examines the consistency across interviews of the order of initiation between pairs of substances as implied by a comparison of ages at first use. Each

comparison was limited to the small subsample of youths (especially for the younger cohort) that reported having used both substances at both interviews.

There were three possible orderings between a pair of substances, A and B: either A preceded B, B preceded A, or they tied (initial use of both occurred in the same year). If respondents provided completely accurate (at least consistent) responses at each interview, ages at first use reported at each interview would have been the same, and the implied precedence ordering would have been the same. However, reported ages were generally not consistent, which led to an ambiguity in dealing with ties. For example, an individual's responses provided at Time 1 might have implied that first use of A clearly preceded first use of B. Yet, at Time 2, the individual might have reported that first use of both substances occurred in the same year, a tie. Further probing might have revealed that first use of A occurred earlier in the same year as first use of B. In which case, the order implied at Time 1 and Time 2 would have been found to have been consistent. Alternatively, probing could have revealed a reversal in order. However, the survey instrument did not include such probing. Therefore, a change from a distinct precedence relationship to a tie represented an ambiguity in whether the individual reported the same sequence of initiation but not a clear contradiction.

In consideration of this ambiguity, two measures of concordance in implied sequence were used: exact and non-reversal. All responses that included a tie at either Time 1 or Time 2 were automatically designated as a match according to the standard of non-reversal.

**TABLE 4**  
**VARIATION IN REPORTED SEQUENCE OF SUBSTANCES ACROSS INTERVIEWS**

| Age at Time 1 | N <sup>a</sup> | Substances involved     | % Concordance      |                           |
|---------------|----------------|-------------------------|--------------------|---------------------------|
|               |                |                         | Exact <sup>b</sup> | Non-reversal <sup>c</sup> |
| 12            | 35             | Alcohol with Tobacco    | 51                 | 77                        |
| 15            | 185            |                         | 52                 | 78                        |
| 12            | 11             | Alcohol with Marijuana  | 36                 | 82                        |
| 15            | 178            |                         | 74                 | 93                        |
| 12            | 9              | Tobacco with Marijuana  | 67                 | 100                       |
| 15            | 131            |                         | 60                 | 92                        |
| 12            | 11             | Alc/Tob with Marijuana  | 73                 | 91                        |
| 15            | 183            |                         | 79                 | 94                        |
| 15            | 9              | Alcohol with Hard Drugs | 100                | 100                       |
| 15            | 7              | Tobacco w/ Hard Drugs   | 100                | 100                       |
| 15            | 9              | Alc/Tob w/ Hard Drugs   | 100                | 100                       |
| 15            | 9              | Marijuana w Hard Drugs  | 100                | 100                       |

<sup>a</sup>Number who reported use of both substances at both interviews.

<sup>b</sup>Percent who reported the exact same order of initiation at each interview.

<sup>c</sup>Percent who did not report a reversal of order of initiation (A then B, became B then A).

## RELIABILITY OF REPORTED PROGRESSION

The proportion of sequences providing an exact match for the ordering of initial alcohol and tobacco use was quite low (51 percent for the younger cohort and 52 percent for the older cohort). Table 5 reveals the nature of this non-concordance for the older cohort; it provides a cross-tabulation of the sequences reported at Time 1 for alcohol and tobacco with the sequences reported at Time 2. On both occasions, about twice as many respondents reported having used alcohol before tobacco (at Time 1, 60 percent, or 110 of 185, reported using alcohol first as opposed to 27 percent who started with tobacco; at Time 2, the ratio was 52 percent versus 31 percent). However, the same individuals did not consistently report alcohol use preceding tobacco use on each occasion. Less than two-thirds (62 percent, or 68 out of 110) of individuals who reported this sequence at Time 1 reported the same sequence at Time 2. Individuals who reported tobacco use preceding alcohol use at Time 1 were even less likely (48 percent, or 24 out of 50) to provide a consistent response at Time 2. Individuals who reported initiating both in the same year at Time 1 were highly unlikely (12 percent, or 3 out of 25) to provide the same response at Time 2. Using the less stringent criterion of no reversals, the concordance in the ordering of reported alcohol and tobacco initiation improved (77 percent to 78 percent) but was still substantially below 100 percent reliable. It would thus appear that the implied sequence of alcohol and tobacco use was not very reliable.

**TABLE 5**  
**VARIATION ACROSS INTERVIEWS IN SEQUENCES INVOLVING ALCOHOL AND TOBACCO FOR**  
**THE OLDER COHORT**

| Substance first used<br>as reported at Time 1 | Number (% by responses at Time 1) of respondents<br>by substance first used as reported at Time 2 |         |         | Total<br>(% at Time 1) |
|-----------------------------------------------|---------------------------------------------------------------------------------------------------|---------|---------|------------------------|
|                                               | Tobacco                                                                                           | Same    | Alcohol |                        |
| Tobacco                                       | 24 (48)                                                                                           | 7 (14)  | 19 (38) | 50 (27)                |
| Same                                          | 12 (48)                                                                                           | 3 (12)  | 10 (40) | 25 (14)                |
| Alcohol                                       | 21 (19)                                                                                           | 21 (19) | 68 (62) | 110 (60)               |
| Total (% at Time 2)                           | 57 (31)                                                                                           | 31 (17) | 97 (52) | 185 (100)              |

The implied sequences of alcohol with marijuana, tobacco with marijuana, and alcohol/tobacco with marijuana were generally more reliable; based on the criterion of exact concordance, 36 percent to 79 percent of individual responses matched. Relatively few individuals reported a sequence that was inconsistent with the gateway theory; i.e., marijuana use rarely preceded use of either alcohol or tobacco. For the older cohort, fewer than 10 percent reported such a sequence at either interview and fewer than 5 percent consistently reported such a sequence at both interviews. More importantly, fewer than 5 percent reported using marijuana before alcohol/tobacco, and absolutely none of the respondents

consistently reported such a response at both interviews. Consequently, the reliability was quite strong (82 percent to 100 percent) under the less stringent criterion of no reversals.<sup>1</sup>

All of the inferred sequences involving hard drug use were completely reliable across interviews (100 percent exact matches). In every case, the age at first use of alcohol, tobacco, and marijuana preceded the age at first use of hard drugs, as expected according to the gateway theory.

## DISCUSSION

A variety of inaccuracies in self-reports of substance use can affect analyses of substance use progression. This study documented the potential impact of two of these biases, unreliability and forward telescoping, using a longitudinal study of adolescents interviewed on two occasions separated by three years. Of course, the nature of the inconsistent responses could differ across populations. These findings are based on a sample of predominately white youths from New Jersey, a densely-populated East Coast state, interviewed during the 1980s. Response reliability could potentially vary across locations, over time, with race/ethnicity, and with the amount of time between interviews. Clearly, additional research replicating the analyses presented in this study are needed to establish the generalizability of any conclusions.

This study found that self-reports of age at first use were affected by both unreliability and forward telescoping, with unreliability the more pronounced effect. The typical difference in the reported age at first use of alcohol was about three years. This is substantial. Based on this measurement error, a 95 percent confidence interval for an individual's age at first use would span 12 years, which is particularly large considering that respondents were only in their teens. The standard deviation for age at first use of tobacco and marijuana was closer to two years. It would appear that adolescents just did not provide very reliable answers to these questions. This reliability might have been enhanced if the survey had used more detailed probes about where respondents were, with whom, and public or private events that may have occurred in temporal proximity to the first use experience. Alternatively, adolescents might be able to provide a reliable response to a direct question about substance use progression if they were asked which substance they used first, second, and so forth.

The analyses also uncovered a consistent bias in reported age at first use across interviews spaced years apart. On average, the reported ages at first use of alcohol and tobacco at Time 2 were about a year older at the second interview. The reported age at first use of marijuana was on average about half a year older. Combining the results for these two cohorts suggests that self-reported ages at first use of alcohol by 18 year olds might differ from those reported by the same individuals at age 12 by 2.6 years, on average. This could mean that the age at first use of alcohol reported by 18 year olds is upwardly biased by 2.6 years, especially for those individuals who initiated use at an early age, assuming that the reports at age 12 were correct. Alternatively, it is possible that individuals

interviewed at age 12 might be underreporting their age at first use, perhaps counting an experience when they had only had a few sips as their first use. In this case, the discrepancy would not represent true forward telescoping but an improvement in accuracy over time. Another possibility is that older teens might feel a greater need to bias their reported age upward in order to provide a more socially acceptable (less deviant) view of their experiences. The average discrepancy from age 12 to 18 inferred from this study for the reported age at first use of tobacco was much less (1.5 years) and even less for first use of marijuana (0.9 years).

If the discrepancies observed were caused by forward telescoping and if forward telescoping tends to continue throughout life, then the reported ages at first use by older individuals could be highly distorted. On the other hand, it seems plausible that forward telescoping could reach an upper limit. Specifically, it is reasonable to expect that as individuals age and become farther removed from their initial use experiences they will tend to increasingly rely on their beliefs about the normative timing of these events when asked to recall them.

It was hypothesized that the sequence of substances used might have been reliably preserved in spite of biases in reported age at first use. The results were actually mixed. The deviations in reported ages across interviews for the various substances were not correlated. Thus, it was not the case that an individual added the same number of years to their reported age at first use of alcohol, tobacco, marijuana, and hard drugs. Due to the unreliability of reported ages at first use, it was often the case that an individual reported having first used alcohol and then tobacco at one interview and then at the next interview reported the opposite sequence, tobacco then alcohol.

The study, however, did find several important measures that were accurately reported. Fewer than 10 percent of respondents who reported use of alcohol/tobacco and marijuana at each interview reversed the order of the sequence they reported. Consistent with the gateway theory, individuals rarely reported having used marijuana prior to alcohol/tobacco. To the extent that the responses provided in this study are typical, analysts who study substance use progression can expect to reliably examine whether use of alcohol/tobacco (whichever comes first) ordinarily precedes use of marijuana among adolescents – especially if ties are evaluated as ambiguous regarding the order of initiation.

This analysis also provides some support to the idea that sequences involving hard drugs are reliably reported. Few individuals reported having used hard drugs at Time 1, and so at most nine responses could be evaluated for any of the sequences involving hard drugs. However, in every single one of these cases, the order reported at Time 1 matched the order at Time 2. In fact, every single sequence matched the gateway theory; first use of alcohol, tobacco, and marijuana always preceded first use of hard drugs. Clearly this information is suggestive but far from conclusive. In order to increase the yield of hard drug

users, future studies of reliability might consider over sampling individuals from high-risk populations.

#### NOTES

- <sup>1</sup> Logistic regression was used to identify covariates of reversals. However, not one of the parameter estimates for variation associated with birth cohort, gender, or age at first use reported at Time 1 was a statistically significant covariate of reversal ( $\alpha=.01$  level). This lack of significant findings was partially attributable to the small sample sizes and the small number of reversals observed.

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