RECALL DECAY AND TELESCOPING IN SELF-REPORTS OF ALCOHOL AND MARIJUANA USE: RESULTS FROM THE NATIONAL HOUSEHOLD SURVEY ON DRUG ABUSE (NHSDA)

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1. Introduction. Knowledge of life-cycle patterns of drug use in the U.S. is based almost entirely on retrospective self-reports of survey respondents. Most evidence for validity comes from studies comparing self-reports of narcotics addicts to hospital and criminal justice records and to the results of urine tests (Nurco, 1985), but such criterion measures are too expensive to obtain in general population surveys. Most evaluations of response errors in general population surveys have used the *reinterview design*, which compares the responses of the same respondents to the same question at two or more interviews. For example, using the National Longitudinal Survey of Youth (NLSY), Fendrich and Vaughan (1994) found that, regardless of interview mode, more than 25% of NLYS subjects who reported lifetime marijuana use in 1984 reported less lifetime marijuana use when reinterviewed in 1988.

In this paper we evaluate response errors using the *repeated cross-section design*, i.e., by analyzing changes in the distribution of responses of the same birth cohorts as measured in cross-sectional surveys conducted in different years. The key advantage of this design for our purposes is that, by combining data from ten National Household Surveys on Drug Abuse (NHSDAs) conducted between 1979 and 1995, we can follow the reports of early drug use by birth cohorts over a period of 16 years without the expense, delay, and possible biases due to panel conditioning and atttrition of a longterm longitudinal followup. The principal disadvantages are 1) there were some changes in NHSDA target population and survey methods between 1979 and 1995 that are confounded with changes in response error (see the next section) and 2) evaluation of differential response error is difficult using repeated cross-sections, because potentially useful covariates are themselves subject to retrospective reporting bias and because we cannot control for individual-level, time-varying covariates.

Both designs assume the true answer stays the same between interviews or between surveys. If we ask a respondent now and a year from now whether he has ever used alcohol, his answers may differ, but the true answer stays the same, provided he does not use it for the first time during the next year. Both designs are better for evaluating measures of initial drug use (incidence) than current drug use, because initial drug use cannot change after a person starts using and because few individuals begin using the major drugs after age 25 (Chen and Kandel, 1995). Another common assumption is that "yes" answers to drug use questions are more likely to be true than "no" answers, because some individuals deny or underreport drug use to avoid perceived risks of sanction. Research literature speaks of underreporting rather than low reliability, with the bias assumed to be downward. If the direction of bias is known to be mainly downward, then the ability of the reinterview design to analyze "gross errors," frequencies of changes from "yes" to "no" and from "no" to "yes," may be less important in evaluating drug use measures.

The next section introduces the NHSDA data used in this paper, assesses possible biases due to changes in the target population and survey methods between 1979 and 1995, and uses the data to show that estimated age-specific alcohol and marijuana incidence rates of birth cohorts decline as the "retention interval," the difference between the ages at interview and first use, increases and that decline is especially steep for alcohol at ages 10-14.

The third section uses exponential decay models of memory loss over time (Sudman and Bradburn, 1973) to adjust incidence rates for retrospective reporting bias and to assess how much difference the adjustment makes for post-World War II trends in alcohol incidence. One of the reasons drug use incidence data are important is that early drug use is thought to strongly predict regular or chronic drug use in later life. To find out whether national incidence estimates predict chronic drug use in later time periods, we need to first adjust incidence estimates for retrospective reporting bias. In a single cross-sectional survey, the positive association between reported early drug use and use at the time of the interview might be an artifact of greater underreporting of early drug use by those who initiated the use of a drug but seldom used it afterwards, a plausible hypothesis in light of psychological theories of the dependence of memory on "rehearsal" or prior retrieval of the same information (Tourangeau et al., 1997), but this paper does not test it. The hypothesis might be better tested using the reinterview design, by controlling for individual-level, time-varying covariates, such as whether an individual stopped using before specified ages.

The final section summarizes some research on changes in birth cohorts' reporting patterns with increasing age at interview to distinguish three possible explanations of downward bias in alcohol incidence rates: *Recall decay* means the decline in the ability to retrieve information from memory as the event to be remembered recedes in time. *Forward telescoping* means the misperception that an event occurred more recently than it really did. Both kinds of memory error need to be distinguished from a tendency to deny or conceal early drug use as an individual ages. An

implication of forward telescoping is that measures of lifetime use, such as whether or not an individual ever used alcohol, are likely to be less biased than measures of age-specific incidence.

2. National Household Survey on Drug Abuse, 1979 through 1995. The NHSDA is a personal-interview survey of individuals aged 12 and older in U.S. households and noninstitutional group quarters, a target population comprising more than 98% of the U.S. population aged 12 and older. The NHSDA has been conducted since 1972, but our analysis is restricted to the years between 1979 and 1995, because, beginning in 1979, private, self-administered answer sheets were used to collect data on alcohol and marijuana use (and on other drugs except cigarettes). The ten surveys between 1979 and 1995 were conducted in 1979 (base n ≈ 7,000), 1982 (6,000), 1985 (8,000), 1988 (9,000), 1990 (9,000), 1991 (33,000), 1992 (29,000), 1993 (26,000), 1994 (22,000), and 1995 (18,000). Given that sample sizes were relatively small prior to 1991, the first part of our analysis pools data between 1979 and 1985 and between 1988 and 1990 to estimate age-specific incidence rates. The unit nonresponse rates of the ten surveys ranged between 15 and 20%. In our analysis, each year of data was weighted to compensate both for oversampling of racial/ethnic minorities and other subpopulations and for differential nonresponse across geographic, demographic, and racial/ethnic strata. The sampling weights were also poststratified to U.S. population totals using census bureau population estimates. (For details, see NIDA, 1980, 1983; SAMHSA 1993, 1995a, 1995b, 1996b).

The NHSDA variables analyzed in this report are derived from respondents' retrospective reports of their ages at first use of drugs. Respondents who never used a drug in their lifetime were asked to leave the answer space blank. Our analyses are restricted to two drug categories- alcohol and marijuana. The wording of the each age-at-first-use instrument changed slightly between 1979 and 1982 and again between 1993 and 1994: In 1979, respondents were asked, *"About how long ago was the first time you had a drink? About how old were you then?"*; from 1982 to 1993, they were asked, *"About how old were you the first time you had a glass of beer or wine or a drink of liquor such as whisky, gin, scotch, etc.? Do not include childhood sips that you might have had from an older person's drink"*; and in 1994 and 1995, they were asked, *"How old were you the first time you had a drink of any alcoholic beverage? Do not include sips from another person's drink."* In 1979, respondents were asked, *"About how old were you the first time you tried marihuana or hash?"*; from 1982 to 1993, they were asked, ***"About how old were you the first time you actually used marijuana or hash, even once?"***; and in 1994 and 1995, they were asked, *"How old were you the first time you used marijuana or hash?"* Small changes in wording can sometimes have large and unexpected effects on response distributions, but there are no obvious differences that would be associated with higher or lower underreporting, and a comparison between the old-questionnaire and new-questionnaire split panels of the 1994 NHSDA showed no significant differences in alcohol and marijuana age-specific incidence rates. The weighted item nonresponse rates of the age-at-first-use items were less than 1.5% for NHSDAs between 1979 and 1995 for both alcohol and marijuana. Given data on the age at first use, we calculated the calendar year of first use by differencing the ages at interview and at first use and subtracting the age difference from the survey year.

Table 1 shows age-specific alcohol and marijuana incidence rates for ages 10-14, 15-19, and 20-24 and 5-year periods between 1961 and 1990. Each age-specific incidence rate equals the estimated number of drug use initiations during the age and period divided by the estimated number of person-years of exposure to risk of first drug use during the same age and period and multiplied by 1000 (i.e., expressed "per 1,000 person-years of exposure"). What distinguishes Table 1 is that we independently estimated each incidence rate using data collected at a range of retention intervals. For example, the first row shows estimated rates for ages 10-14 during 1961-65. Based on data collected in the pooled 1979, 1982, and 1985 NHSDAs, the alcohol incidence rate equals 31.8 initiations per thousand person-years of exposure. Based on data collected in the pooled 1994-1995 NHSDAs, the same rate equals 19.1. Varying the date of the survey is equivalent to varying the retention interval: For the birth cohort aged 10-14 during 1961-65, the 1979-to-1985 NHSDA data were collected from 14 to 24 years after the 1961-1965 reference period, and the 1994-95 NHSDA data were collected from 29 to 34 years after the reference period. The survival percentages from 1979 to 1995 of the birth cohorts range from 88% to 99% (Table 1, 5th column), higher than the follow-up rates in most national reinterview designs. The bias due to differential mortality of heavy drug users in our analysis is not necessarily larger than the bias due to differential loss to follow-up of heavy drug users in reinterview designs.

Different birth cohorts entered the 1979-to-1995 data collection period at different ages and retention intervals. Assuming invariance of the recall decay process across birth cohorts, we can use a statistical model to summarize information about the decline of reporting across retention intervals ranging in length from about 0 to 30 years. Table 1 shows only a subset of the data that we used to estimate such models, specifically the rates estimated using the earliest available and most recent NHSDAs (1994-95) for each birth cohort. The complete data table shows, for each drug, period, and age at first use, the incidence rates estimated using the pooled 1979, 1982, and 1985 NHSDAs; the pooled 1988 and 1990 NHSDAs; the pooled 1991-93 NHSDAs; and the pooled 1994-95 NHSDAs, except that,

for the 1981-85 reference period, the pooled 1988 and 1990 NHSDAs are the earliest available survey years and, for the 1986-90 period, the pooled 1991-93 NHSDAs are the earliest available years. For each of alcohol and marijuana, the complete table shows that, with a few modest exceptions, mainly for alcohol at ages 20-24, incidence rates decline monotonically with increases in the retention interval.

3. Modeling recall decay using the repeated cross-section design. To model the estimated alcohol and marijuana incidence rates, summarized in Table 1, we used the exponential decay model of memory loss proposed by Sudman and Bradburn (1973). Letting R_{PAY} denote the rate for period P, age A, and survey years Y, the model is

$$R_{PAY} = \alpha_{PA} \exp[- \beta_A \, av(Y - P)] \, \xi \,, \quad (1)$$

where av(Y - P) denotes the average length of the retention interval and ξ denotes a multiplicative stochastic error. The model has two kinds of parameters: α_{PA} is the "baseline rate," interpreted as the rate when the retention interval equals zero. β_A is the recall decay parameter, interpreted as the proportional change in the estimated incidence rate associated with a one-year increase in the average retention interval. The subscript A is needed because, for both drugs, the rate of recall decay varies significantly across the three ages of initiation 10-14, 15-19, and 20-24.

Taking natural logs reduces the model to linearity, so we can estimate the parameters using linear least squares. To adjust for differences in the standard errors of the estimated rates (see Table 1), the estimation weighted each logged rate by the inverse of its estimated variance, based on Taylor Series approximation of the standard error of the logarithm. The model fit well, with coefficients of determination greater than .99 for each of alcohol and marijuana. The goodness-of-fit results partly from the large number of parameters, 21, used to model 63 rates for each of alcohol and marijuana. It makes sense to allow a baseline rate for each combination of period and age, accounting for 18 of the 21 parameters.

For alcohol incidence, the estimated recall decay parameters equal .059 (standard error = .004) for ages 10-14, .012 (.002) for ages 15-19, and .002 (.007) for ages 20-24. For marijuana incidence, the estimated recall decay parameters equal .039 (.005) for ages 10-14, .019 (.003) for ages 15-19, and .021 (.006) for ages 20-24. For both drugs, recall decay is significantly higher at ages 10-14 than at ages 15-19 or 20-24, a pattern suggestive of forward telescoping, because individuals initiating drug use at ages 10-14 are able to forwardly telescope the event into more remaining ages and years of life than individuals initiating drug use at ages 15-19 or 20-24. The estimated recall decay parameters are significantly higher for alcohol than for marijuana at ages 10-14 (.059 vs. .039) and higher for marijuana than for alcohol at ages 15-19 and 20-24. Recall decay is not significantly different from zero for alcohol incidence at ages 20-24.

Five years after the reference period, there is already about a 25-percent reduction in reported alcohol incidence (i.e., $1 - e^{-5(.059)} \approx .25$), as compared with only an 18-percent reduction in reported marijuana incidence (i.e., $1 - e^{-5(.039)} \approx .18$). Perhaps episodes of marijuana use are more salient than alcohol use in many respondents' memories, because they used marijuana much less frequently and because marijuana is illegal.

Yet there is an important caution in interpreting the model: As in the reinterview design, aging effects in reporting error are confounded with period effects. In following either a reinterview panel or a birth cohort over time, we cannot tell whether changes in behavior are due to aging, or to covariates of aging such as the length of the retention interval, or rather to changes associated with historical periods. For example, drug use incidence rates estimated using 1994-95 data might be lower than the same rates estimated using 1979-85 data not only because the retention interval is longer but also because drug use was more socially undesirable or perceived as more harmful in the mid-1990s than in the late 1970s and early 1980s. Indeed, data from the University of Michigan's Monitoring the Future survey show that the percent of twelfth graders who perceived "great risk" in using marijuana "occasionally" increased from about 15% in 1979 to about 38% in 1991 before declining to about 28% in 1994 (Johnston et al., 1995).

Figure 1 addresses the question of how much difference retrospective reporting error makes for alcohol incidence trends during the post-World War II period. Specifically, the figure compares trends in alcohol incidence at ages 10-14 and 15-19 based on the pooled 1994-95 NHSDAs ("10-14" and "15-19") with *adjusted* trends using the baseline rates (α_{PA}'s in Eq. 1) of the exponential decay model ("10-14 ADJ" and "15-19 ADJ"). Figure 1 shows that the effect of the adjustment is to raise the levels of the trend at ages 10-14 and 15-19, much more so for estimated rates during the 1960s, when the average retention interval using 1994-95 data is long, than during the 1980s, when the average retention interval is short. In general, the failure to adjust for retrospective reporting bias operates to make trend lines that are declining look stable and trend lines that are stable look increasing. In Figure 1, the adjustment also makes an interpretation based on period effects more plausible: In the unadjusted series based on 1994-95 data, the rates at ages 10-14 and 15-19 follow different trajectories in time, with incidence at ages 10-14 increasing during the early 1980s while incidence at ages 15-19 is declining. In the adjusted series, both age-specific rates increase to a peak in the early 1970s and decline thereafter. Unlike the unadjusted time series, the adjusted time series of alcohol incidence at ages 10-14 and 15-19 look parallel.

4. Recall decay, forward telescoping, and intentional concealment. To distinguish the three explanations of

underreporting, we examined covariation over time in the percentages of birth cohorts reporting never using drugs and initiating drug use at different ages. For alcohol incidence in cohorts born in the 1950s and early 1960s, the analysis suggested forward telescoping: As the percentage of a cohort reporting incidence at ages 15-to-19 increased between interview ages 15 and 19, the percentage reporting initiation at ages less than 15 declined at about the same rate. Moreover, the percentage reporting initiation before age 15 continued to decline with increasing age at interview even after the percentage reporting never having used alcohol reached approximate stability at about age 22.

5. Conclusions and recommendations. The repeated cross-section design can provide a cost-effective alternative to reinterviews in evaluating data quality. This paper used the cross-section design to show that NHSDA estimates of alcohol and marijuana incidence are biased downward by response error, especially at ages 10-to-14. The downward bias increases with the retention interval, making stable trend lines look increasing when estimated using a single survey. Detailed cohort analyses suggest forward telescoping, with the implication that measures of lifetime drug use, such as whether an individual has ever used alcohol, are less biased than measures of drug use incidence at specific ages. Marijuana incidence rates are biased downward at ages 15-to-19 and 20-to-24, as well as at 10-to-14, suggesting intentional concealment among older respondents. Yet these interpretations based on the association between response distributions and retention interval length may be incorrect, because age at interview, hence retention interval length, is confounded with the historical period during which the data were collected.

We recommend that cross-sectional estimates of trends in drug use incidence should be adjusted for retrospective reporting bias, using statistical models similar to those applied in this paper, and that researchers should continue to prefer longitudinal research designs (Chen and Kandel, 1995; Johnston et al., 1995) to analyze developmental patterns of adolescent drug use. Reinterview designs are better for analyzing differential response error, but results-to-date do not show whether downward bias in reports of early drug use is greater among one-time or experimental drug users than among regular or habitual users, a hypothesis for future research.

6. References

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Table 1. Age-specific rates of first alcohol and marijuana use by period and NHSDA survey year.

Period	Age at First Use	Ranges: Min in 79 to Max in 95			Rate(se) per 1,000 person-years at risk by drug and NHSDA survey year:			
					Alcohol		Marijuana	
		Age at Inter-view	Retention Interval	Percent Survival[2]	Earliest NHSDAs[1]	Pooled 94-95 NHSDAs	Earliest NHSDAs[1]	Pooled 94-95 NHSDAs
1961	*10-14*	24-48	14-34	95%	31.8 (2.3)	19.1 (1.5)	2.5 (0.6)	1.1 (0.4)
-65	*15-19*	29-53	14-34	93%	158.0 (6.4)	112.8 (5.5)	13.4 (2.0)	7.1 (1.2)
	20-24	34-58	14-34	88%	119.1 (11.9)	116.5 (11.4)	7.1 (1.6)	5.1 (1.7)
1966	*10-14*	19-43	9-29	96%	48.4 (2.2)	29.7 (2.3)	18.2 (1.5)	11.0 (1.3)
-70	*15-19*	24-48	9-29	95%	176.2 (5.3)	157.4 (5.4)	67.9 (3.4)	47.1 (3.1)
	20-24	29-53	9-29	93%	122.5 (9.1)	119.4 (7.6)	40.9 (3.0)	32.6 (3.3)
1971	*10-14*	14-38	4-24	97%	72.2 (2.7)	38.2 (2.0)	38.2 (1.9)	20.9 (1.5)
-75	*15-19*	19-43	4-24	96%	201.3 (4.6)	166.9 (5.3)	108.4 (3.4)	86.6 (3.9)
	20-24	24-48	4-24	95%	106.8 (8.7)	126.7 (7.2)	48.4 (3.1)	38.8 (3.1)
1976	*10-14*	12-33	0-19	97%	98.7 (3.3)	41.4 (1.7)	44.0 (2.3)	25.5 (1.3)
-80	*15-19*	14-38	0-19	97%	198.0 (5.6)	179.5 (4.4)	106.6 (3.6)	89.6 (3.1)
	20-24	19-43	0-19	96%	113.0 (8.0)	108.0 (6.9)	38.6 (2.4)	29.7 (3.1)
1981	*10-14*	13-28	3-14	98%	64.5 (3.2)	47.3 (2.0)	31.8 (2.4)	21.9 (1.5)
-85	*15-19*	18-33	3-14	98%	182.6 (5.1)	163.1 (3.3)	89.8 (3.3)	74.4 (2.7)
	20-24	23-38	3-14	98%	95.4 (8.6)	97.0 (5.7)	25.8 (2.8)	19.7 (1.7)
1986 -	*10-14*	12-23	1-9	99%	73.9 (1.7)	49.6 (1.7)	20.8 (1.1)	16.6 (1.0)
90	*15-19*	16-28	1-9	99%	184.9 (2.6)	162.6 (3.4)	77.6 (2.4)	68.6 (2.5)
	20-24	21-33	1-9	98%	98.1 (5.0)	103.5 (4.8)	22.8 (1.4)	19.4 (1.6)

1. For the 1961-65 through 1976-80 periods, the earliest NHSDAs are the pooled 1979, 1982, and 1985 surveys; for 1981-85, the earliest are the pooled 1988 and 1990 surveys; and for 1986-90, the earliest are the pooled 1991-93 surveys. See the text for a description of the complete data.
2. NCHS, 1993, 1979-81 synthetic life table.

Figure 1. Alcohol incidence rates at ages 10-14 and 15-19 by period. Estimated using 94-95 data and adjusted for recall error ("ADJ").