# Twin Studies of Alcohol Consumption, Metabolism, and Sensitivity

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## OVERVIEW

It is a common observation that individuals differ greatly in their consumption of alcohol and in their sensitivity to it. Some people appear greatly affected by even small doses; others consume large amounts of alcohol with little apparent effect on their behavior or performance. The causes of this normal variation, both in consumption and sensitivity, are of considerable interest, partly because they may provide clues to the etiology of the abnormal condition, alcoholism.

Comparison of identical (MZ) and nonidentical (DZ) twins is perhaps the best available design for estimating the relative contributions of environmental and genetic factors to individual differences. We have conducted a laboratory study of alcohol metabolism and psychomotor sensitivity in > 200 twin pairs. Serum enzymes and hematological variables used to diagnose alcohol-related liver damage were also measured in these twins. Independently, we have studied drinking habits in nearly 4000 twin pairs who responded to a mailed questionnaire. Detailed reports of these studies have appeared elsewhere; in this paper, I highlight some of the insights we have gained into causes of normal individual differences in drinking habits, ethanol metabolism, and sensitivity to alcohol and the relationships between these variables.

### Alcohol Consumption

A questionnaire, which included items on drinking patterns, was mailed to all 5967 pairs of adult ( > 18) twins enrolled on the Australian Twin Register. Completed replies were obtained from 3810 pairs, a 64% pairwise response rate, including 1233 MZ female, 567 MZ male, 751 DZ female, 352 DZ male, and 907 unlike sex pairs. The distribution of alcohol consumption reported by our volunteer twin sample was similar to that found in a random sample of the population surveyed by the Australian Bureau of Statistics. Because the distribution is highly skewed, genetic analysis was carried out on log-transformed scores.

Alternative hypotheses concerning the causes of individual differences in alcohol consumption were fitted to the mean squares for MZ and DZ twins.

One cause considered was additive genetic variance, which produces differences between MZ pairs but not within them and is divided equally between and within DZ pairs. Two sources of environmental variance are distinguished: exogenous influences that make siblings differ from each other (individual or specific environment—E1) and those that affect both cotwins but differ between twin pairs (shared or family environment—E2). The distinction is important; E1 estimates the influence of environmental factors unique to the individual and also includes measurement error, whereas E2 includes the influence of social and familial environments that are of primary interest to sociologists, for example. Models comprising various sensible combinations of these parameters were fitted to the data by the method of iterative weighted least squares, and criteria including goodness of fit and parsimony were used to decide upon a preferred hypothesis for the cause of individual differences (see Eaves et al. 1978).

The median age of the sample was ~30 years, so separate analyses were performed for twins aged 30 and under and for pairs over 30. Percentages of variance in alcohol consumption due to the three sources of variance considered are shown in Table 1 (Jardine and Martin 1984).

These percentages are calculated from the preferred models, and because the sample is subdivided four ways, the power to detect all three sources of variance in a subgroup is low if any one source is small (Martin et al. 1978). Thus, it is unlikely that there is no influence of shared environment on females nor of genetic factors on older males.

Our results confirm the importance of genetic factors in determining individual differences in alcohol consumption and echo the results of other twin studies (see, e.g., Kaprio et al. 1981). However, the differences in etiology between age and sex groups are highly significant, and our analysis makes the point that the relative importance of genetic and environmental factors depends crucially on the group under consideration. In males, genetic differences are important in youth but are increasingly overshadowed by environmental influences shared by brothers as they age. Genetic factors are of major importance in determining the alcohol consumption of females, al-

**Table 1**

Sources of Variance (%) for Alcohol Consumption According to Sex and Age of Twins

|  | Females | | Males | |
|---|---|---|---|---|
|  | ≤30 | >30 | ≤30 | >30 |
| Individual environment | 42 | 45 | 34 | 49 |
| Shared environment | — | — | 21 | 51 |
| Genetic | 58 | 55 | 45 | — |

though both genetic and individual environmental variances for this measure increase considerably with age. In further analyses, we have shown that the causes of variation in female alcohol consumption depend critically on marital state. In unmarried females, genetic factors account for as much as 76% of the variance, whereas in married females, it is as low as 31% (Heath et al. 1989 and this volume). These patterns echo the causes of variation in age of onset of drinking; primarily social factors seem to determine when males start drinking, whereas genetic factors play a larger role in determining when females reach this landmark (Heath and Martin 1988; Heath et al., this volume).

We are currently following up this large twin sample 8 years after the initial contact to investigate the stability and sequelae of different drinking patterns and the extent to which genetic and environmental factors modify persistence and change in these behaviors over time. This study will be augmented with a new cohort of 18- to 26-year-old twins to resolve cohort versus developmental effects as the cause of the age differences we have observed in genetic architecture, and with the parents, spouses, and siblings of both new and already registered twin cohorts to address more subtle questions about genetic and environmental causes of family similarities and differences in drinking habits.

## Alcohol Metabolism

In a laboratory study, we measured psychomotor performance in 206 pairs of 18- to 34-year-old twins before consuming alcohol and three times at hourly intervals after a standard dose of ethanol (0.75 g/kg body weight) was ingested. Blood alcohol concentration (BAC) was measured at frequent intervals after ingestion. There were 43 MZ female, 42 MZ male, 44 DZ female, 38 DZ male, and 39 DZ pairs of opposite sex. Repeat measurements were obtained for 41 of these pairs approximately 4 months after their first trial (Martin et al. 1985a,b).

At least six assays for blood ethanol were made from finger-prick samples on each subject. To correct for slight inequalities in sampling times, a curve was fitted to the BACs for each subject, from which the peak BAC, time to peak, and the rate of elimination were calculated. Repeatabilities (test/retest reliabilities) between occasions (averaging 4.5 months apart) were surprisingly low. For the individual readings, the average repeatability across different sampling times was only 0.64, 0.66 for peak BAC, 0.39 for rate of elimination, and a barely significant 0.27 for time of peak. Because the correlation between duplicate assays of the same sample was 0.97, little of this nonrepeatable variation can be attributed to errors in aliquot measurements or to machine fluctuations.

Genetic analysis found heritabilities of $0.62 \pm 0.06$ for peak BAC and $0.49 \pm 0.07$ for rate of elimination, but no significant genetic variance could be detected for time to peak. Heritabilities do not differ significantly from the respective repeatabilities of the BAC parameters, suggesting that all repeatable variation between people in the way they metabolize alcohol is determined genetically. Our results are at variance with those of Vesell (1972), who estimated a heritability of 0.98 for alcohol elimination rate in 14 pairs of twins, but are close to those of Kopun and Propping (1977), who used a larger sample of 40 pairs and found a heritability of 0.41. Our much larger sample of twins confirms the extensive role of environmental influences on rates of alcohol metabolism and suggests that these are ephemeral in nature and cannot be detected systematically over a period of months.

Our subjects were instructed to have a light, nonfatty breakfast before the trial and not to drink after midnight the previous evening. But in an effort to identify the ephemeral influences that account for so much of the variance in ethanol metabolism, we examined the relationship between BACs and the size of breakfast eaten on the day of the trial, and also whether the subject had consumed any alcohol on the previous evening. Neither factor accounted for more than several percent of the variance in BACs. Larger correlations were obtained with normal weekly alcohol consumption and also with the number of years that the subject had been drinking regularly. However, these variables still only accounted for 5–10% of the variance in BACs; in any case, we have shown that they are fairly stably reported and quite heritable, particularly in women (see above). Similarly, significant correlations were found between BACs and physical variables, including weight, adiposity, and lung function, although the relationships were a complex function of age, sex, and time of sampling. Once again, however, these physical variables are fairly stable over a period of several months, are moderately to highly heritable (Clark et al. 1980; Gibson et al. 1983), and will therefore not explain much of the ephemeral environmental variation detected.

Our study (Martin et al. 1985a) could only provide the broadest description of major influences on alcohol metabolism, namely, genetic factors and ephemeral environmental factors. We have failed to identify the nature of these environmental influences, although we have established that they are not merely due to measurement error. Further pharmacological experiments of the most traditional kind—investigations of the influence of $A$ on $B$—are needed to identify and quantify these influences, which may well reside in quite subtle aspects of life-style, small-scale life events, and associated moods.

Polygenic factors that affect drinking habits and adiposity also appear to influence ethanol metabolism but are unlikely to account for more than a small proportion of variance in the latter. There is not yet sufficient evidence

of polymorphism at alcohol or aldehyde dehydrogenase loci in Europeans to account for the observed genetic variance in BACs (Goedde et al. 1979), although this may change with the availability of DNA probes for these enzymes. Clearly, we have barely begun to explain individual differences in alcohol metabolism.

## Psychomotor Sensitivity to Alcohol

Twins taking part in the above experiment were trained to plateau on a variety of psychomotor tasks, measured once before and three times after alcohol ingestion at hourly intervals. From previous work, the tasks had all been found to exhibit a monotonic relationship between alcohol dose and psychomotor response (Franks et al. 1976). We were therefore in a position to ask whether genetic factors that affected individual differences in psychomotor response to alcohol could be identified (Martin et al. 1985b). On the basis of work by Martin and Eaves (1977), an analysis was designed that would distinguish genes affecting all four measurements of psychomotor performance on a given task (general genetic factor) from independent genes that only influenced performance on the three postalcohol trials, but not the prealcohol trial (alcohol genetic factor).

Our psychomotor battery measured four essentially independent aspects of performance, which we term coordination, steadiness, cognitive time, and reaction time. We detected alcohol-specific genetic variation for all four factors. That is, there are genetic differences between individuals that help determine how one will perform at a given task under the influence of alcohol, and these genes are quite independent of those that determine one's general level of performance with or without alcohol. Yet another viewpoint is that an environmental factor, alcohol, unmasks genetic variation between people, which is hidden when they are sober.

The most striking example of this phenomenon in our study was the body sway task. Individuals were asked to stand with their eyes closed on a platform beneath which was a transducer that measured the amount of sway in the forward/backward dimension. Not surprisingly, sway was a function of center of gravity, so raw scores were corrected for height and weight before analysis. Table 2 shows the proportions of variance due to genetic and environmental factors for males at each trial.

Genetic differences are either general in influence or are only expressed after alcohol ingestion. Environmental variance is partitioned between those influences affecting performance on all four occasions (general factor), which might include sporting prowess and general state of well-being on the day, and specific environment, which influences a particular trial and that trial only. It is significant that estimates of the specific environmental variance are

**Table 2**

Body Sway in Male Twins: Variance (%) in Performance Before and After
Alcohol Ingestion

|  | Environment | | Genetic | |
| --- | --- | --- | --- | --- |
|  | general | specific | general | alcohol |
| Before alcohol | 4 | 26 | 70 | — |
| 1 hr after | 7 | 26 | 23 | 44 |
| 2 hr after | 21 | 26 | 13 | 40 |
| 3 hr after | 55 | 13 | 22 | 10 |

very close to independent estimates of the unreliability of the measurements
from the test/retest data.

Genetic variance, as discussed above, is partitioned between that due to the
general factor affecting performance, both before and after ingestion, and the
alcohol genetic factor that reflects genetic differences exposed only in the
presence of alcohol. The trends in Table 2 are striking. Before alcohol
ingestion, a set of genes that affects body sway accounts for 70% of variance
in the sober state. One hour after ingestion, these genes account for only 23%
of the variance, and a new set of genes, whose effects are only "switched on"
in the presence of alcohol, account for 44% of variance. As the influence of
alcohol diminishes, these genes account for less and less of the variance—
40% at 2 hours and only 10% at 3 hours after ingestion (Boomsma et al.
1989).

Similar, though smaller, alcohol-specific genetic effects were found for the
other dimensions of psychomotor performance and also for physiological
variables, including heart rate, blood pressure, and skin temperature. There
were also large genetic effects on subjective impressions of drunkenness
(Neale and Martin 1989) and on willingness to drive a car after alcohol
ingestion (Martin and Boomsma 1989). Clearly, there are genetic polymor-
phisms that have great influence on sensitivity to alcohol. To what extent are
these polymorphisms the same as those reflected in genetic variation for
drinking habits and ethanol metabolism?

A first approach to this question is to examine the correlates of change
scores in psychomotor performance. We calculated the difference between
performance before alcohol ingestion and 1 hour after (the time of maximum
effect for most measures) and carried out stepwise multiple regression on a
number of independent variables, including measures of drinking habits,
BAC at 1 hour postingestion, and personality measures, incuding extraver-
sion and psychoticism. For body sway in males, normal weekly alcohol
consumption accounted for 11% of the change score, reflecting the fact that
heavier drinkers were less steady than average before alcohol but more steady

after alcohol. Only a further 2% of variance was accounted for by BAC, and another 3% by the number of years of regular drinking by the subject. For body sway in females, regular alcohol consumption and BAC each accounted for < 2% of variance in the change score. For some other psychomotor tasks, notably hand/eye coordination, BAC did account for somewhat more of the variance in change score.

The striking finding remains, however, that psychomotor change scores are predicted very poorly by BAC, at least within the range of BACs obtained in our experiment (at 1 hr, mean 89 mg/100 ml EtOH, s.d. 18 for males; 95 ± 19 for females). Our results suggest that very little of the genetic variation in psychomotor sensitivity to alcohol can be accounted for either by variation in drinking habits or by BACs. This suggests that clues to the biochemical basis of variation in alcohol sensitivity in Europeans will not be found in the early parts of the metabolic pathway. To this end, we are now recontacting the twins who took part in this experiment, on whom valuable sensitivity data have been obtained, to obtain blood samples with a view to establishing Epstein-Barr virus lines. As probes for genes implicated in ethanol sensitivity become available (neurotransmitters?), we will look for associations between genetic variants and our earlier phenotypic measurements of alcohol sensitivity.

## How Well Does Psychomotor Performance Discriminate between Groups with Different Blood Alcohol Levels?

As already noted, we observed low correlations between psychomotor performance and BAC after alcohol ingestion. We may ask how well these psychomotor measures discriminate between persons with BACs above or below a certain level, e.g., 80 mg/100 ml.

One hour after alcohol ingestion, 59 males had BACs < 80 mg/100 ml, and 139 had BACs greater than this level. The best discriminant function of performance variables measured at this time only classified 60% of these cases correctly. At other times, in both males and females, the best discrimination achieved between groups was only 71%. Thus, at any given time, the fact that individuals had a BAC greater than or less than 80 was a very poor guide to their performance on our battery of tests.

This result may arise from a restriction of range in both performance measures and BACs at a given time. Consequently, we recalculated the discriminant function by regarding each BAC reading and its associated performance measures at a given time as a separate case. The sets of observations are thus not independent, because each individual is now regarded as four "cases," but the analysis should afford the maximum opportunity for performance measures to discriminate between the two classes of BACs over

a wide range of values, including the prealcohol values at which BAC was zero. Because the aim was to discriminate between BACs greater than or less than 80, regardless of sex, all 412 individuals were included in the analysis, generating 1648 cases.

At least one variable from each of the four groups of psychomotor measures contributed to the discriminant function and two measures each from the body sway and pursuit rotor tests, which appear to be the most discriminating tasks. Although the function made a highly significant discrimination between groups on either side of the BAC of 80 mg/100 ml, there is a great deal of overlap between the two groups. About 29% of cases with actual BACs < 80 performed poorly enough to fall into the group predicted to be > 80, whereas 34% with actual BACs > 80 performed well enough that they were predicted to fall into the low BAC group. Only 69% of cases were correctly classified. A further discriminant analysis attempted to classify BACs into three groups: 0, 1–80, and > 80 mg/100 ml; the classification results are shown in Table 3. Of those who were actually completely sober, 9.5% of cases performed so badly that they were predicted to have BACs > 80, whereas of those who actually did have BACs > 80, 19.3% were predicted to fall into the sober group. Overall, only 54% of cases were correctly classified.

We conclude that our battery of tests provides only very crude predictive power about the BACs of individuals. Conversely and more importantly, BACs in the considerable range that we have observed are a poor predictor of psychomotor performance on our battery of tests. This range was 0 mg/100 ml to 162 mg/100 ml, including 412 zero readings; the mean of nonzero readings is 83 and s.d. 17. This range of BACs is the main focus of legislative and police attention in attempts to lower the road toll.

Two possible interpretations of our results are (1) the psychomotor tests we have used have little to do with driving competence, and our results are

Table 3

Classification Results for Discriminant Analysis between BACs on the Basis of Psychomotor Performance Scores

| | Predicted group (%) | | | |
|---|---|---|---|---|
| | 0 | 1–80 | >80[a] | n |
| Actual group | | | | |
| 0[a] | 72.5 | 18.0 | 9.5 | 411 |
| 1–80 | 33.1 | 32.1 | 34.8 | 202 |
| >80 | 19.3 | 19.8 | 60.9 | 653 |

54% of cases correctly classified.
[a]Concentrations are milligram per milliliter.

therefore irrelevant for practical purposes; or (2) preventive action would be better aimed at testing driving competence than measuring concentrations of alcohol or other drugs in the blood. It is ironic that the traditional test for drunkenness in many countries, in which the suspect was asked to walk a white line (a task closely related to our body sway test) was superseded by blood alcohol testing. Perhaps those interested in road safety should be pressing for roadside psychomotor testing rather than for lower legal BACs. If the psychomotor tasks we used in our study have any correlation with driving safety, such legislation penalizes many drivers who are competent and leaves unpenalized many drivers who are not competent.

In conclusion, our studies have shown the important role played by genetic differences in determining how much people drink and how they are affected by alcohol. In an ideal world, each individual would determine his own level of responsible drinking, but this would ignore individual differences in responsibility and judgment.

## ACKNOWLEDGMENTS

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## COMMENTS

**Schuckit:** Did you determine the reproducibility of the body sway data?

**Martin:** Yes, it was about 0.8.

**Chakravarti:** The data that Andrew presented, concerning frequency and quantity of drinking, you said this was self-reported data?

**Heath:** Yes.

**Chakravarti:** Are you making an attempt to verify it?

**Martin:** We have test-retest data. In that particular study, we had the same questions answered three months later by 100 individuals. It's not a very large sample. Test-retest correlations were about 0.8 for the quantity

and frequency questions. Of course, that doesn't answer the question about validity.

**Heath:** We are trying in the follow-up to actually get information from informants about it.

**Chakravarti:** Given all the social taboos now about drinking, I'm just wondering whether there are changes in your classification.

**Heath:** In the Virginia study, we asked people to report about themselves, their twins, their parents, and so on. We get correlations on the order of about 0.7–0.75 between what an individual says and what other members of the family say about that individual. It's not an ideal measure. Obviously, we would rather have someone from the outside, as it were.

**Reich:** Is your repeatability different in different parts of the distribution, since the alcohol consumption curve is really skewed?

**Martin:** The repeatability of alcohol consumption?

**Reich:** Consumption frequency and frequency. If they're real alcoholics, they may not be able to know exactly.

**Heath:** We don't have enough data points. We only had a retest for about 120.

**Begleiter:** I'm always a little surprised about the lack of BAL reliability over time. Maybe this is because for the most part people only take one parameter out of the wealth of data included in the whole BAL curve. For instance, you have rise time, decay time, onset time, and frequency. Typically, people only look at one thing, which is peak, and, of course, most people don't find it to be highly reliable.

**Martin:** I showed you the reliability and heritability at each time point and in the four measured statistics, the four computer statistics, as well. I looked at the raw time point data there, and the best reliability was around 0.68 for a single time point. The problem is that when you then start combining those into computer statistics or working out the first differential, which is the maximum, you just combine the zeroes and they've actually even got worse characteristics.

**Li:** For the test-retest reliability, was what you stated for both without alcohol and with alcohol?

**Martin:** The test-retest reliability was higher after alcohol than before al-cohol—about 0.8 for females, and a bit lower for males.

**Begleiter:** This is in direct contradiction to the Nagoshi and Wilson data.

**Martin:** That's test-retest data. I can't remember how large their test-retest sample was. We had about 80 subjects in our test-retest sample.

**Begleiter:** They had a larger sample than that.

**Schuckit:** We find a high level of similarity testing the same man on three different occasions.

**Martin:** For psychomotor?

**Schuckit:** For body sway. We test men at two different doses of alcohol and we find a high correlation between the amount of increase in sway after low dose and the amount of increase after high dose. It's very, very similar. I don't have data on the same man at the same dose twice, but my data would be more similar to yours than it would be to Nagoshi-Wilson's.

**Martin:** We need to look at that Nagoshi and Wilson data. I think there was something problematic about the way they did their analysis.

**Reich:** Since the biology of the ascending and descending forces on the curve was different, wouldn't you expect the heritability and the performance characteristics to be different also?

**Martin:** It's so difficult to get anything on the ascending path because it's so quick. Certainly, getting breath alcohol measurements during that time is useless anyway because there is so much residual breath alcohol. Unless you are taking samples every five minutes, you just miss it for most people.

**Risch:** When you did modeling with two genetic components, you said upon alcohol consumption there was a new heritability elicited. Is this reflecting the fact that the heritability goes up, basically, after alcohol consumption?

**Martin:** Yes, but the fascinating thing is, if you do it on the raw measurements, you can actually see the variance go up dramatically after alcohol, and you can actually show that all that new variance is genetic, and environmental variance is actually more or less remaining as a constant. Of course, the problem is when you then start studying the proportion, you see that the environmental variance goes down as a proportion, but actually, in absolute terms, it's constant.

**Heath:** It's not just the case that you can estimate a single common factor with increase in loading?

**Martin:** No. You have to put a second factor in there to account for it,

which is a very clumsy way to do it. We have redone it as a time series problem with the inputs at each time point, which is the correct way to do it, and you can actually show a large chunk of new genetic variance coming at time 1, and that just gets carried forward, but diminishes at the subsequent time points. That's the only innovation you need to put in.

**Risch:** Did you do any regression on the other covariates, like weight and blood alcohol concentration? I would think those things are heritable also.

**Martin:** I didn't in the genetic model because from just the correlation tables that I showed you the correlations were so slight that you're only going to mark up 4% or 5% variance at most due to any of the covariates. If that is a phenotypic correlation, that is going to split between genetic and environmental effects anyway, so you're going to be looking at effects down around 2% or 3% of the variance. Even if I can estimate that, who cares?

**Chakravarti:** But those are all individual, because you have cases where you found an effect not at time zero or you found an effect in females even after correcting the measurement for body weight. So there may be other interactions.

**Martin:** Yes. That shows that our attempts to dose for weight are not good enough. There are all sorts of inner body fat deposits which even taking some subscapular readings and subcutaneous readings are not going to fix up. My guess is that, while we are trying to do that very carefully, there is still such a huge range of variation left in BAC that other factors are operating which are quite independent of those physical kinds of things.

**Risch:** High-weight people got a higher dose, right?

**Martin:** Yes.

**Risch:** They also showed up with a higher blood alcohol content; is that right?

**Martin:** Yes.

**Risch:** Maybe you overcompensated, because they got a higher dosage of alcohol.

**Martin:** Yes, but we're talking about a correlation of 0.2–0.25, which was the maximum correlation with weight or with adiposity.

**Risch:** I didn't know what happened when you put them all together. You probably did that.

**Martin:** As I say, that would account for that 2%, or 3%, or 4% variance, but there is a massive chunk of variance out there that is not accounted for in that.

**Li:** There is a new observation which I think is probably important in understanding some of these differences, and that has to do with first pass metabolism, that is now known in humans and is really quite significant when the dose of alcohol is low. But with the dose you're giving and which we normally give—which is really about half a bottle, not quite a whole bottle of wine...

**Schuckit:** What he gave is close to six drinks.

**Li:** Yes, five to six drinks. Then, first pass metabolism can be quite significant because of alcohol dehydrogenase in the stomach. It is almost absent in women and it's quite prominent in men.

**Martin:** I don't know what you mean by first pass metabolism.

**Li:** When you drink, the alcohol is metabolized and never reaches the blood stream, so you are measuring breath (and we are too) and blood alcohol, and you don't see the amount because it has been metabolized already.

**Martin:** Before it even gets there?

**Li:** Yes. It has been shown quite recently that it is due to the metabolism by the stomach and not first pass through the liver.

**Martin:** And you're saying that could account for that sex difference?

**Li:** Sex difference, as well as maybe differences in pernicity of drinking, because that changes with drinking, and also, individuals differ in the amount of the forms present. It's a different form. We're calling it $\sigma$ ADH.

**Reich:** The more you drink the less you have?

**Li:** Yes. Chronic alcoholics have less of a first pass.

**Heath:** What are the typical drinking histories of the people who agreed to participate in that study?

**Martin:** There was a range. The age range was 18–34, with the preponderance toward the younger people. There were quite a number of naive drinkers in the study. We tried to get young people who hadn't shot

their livers, but, nevertheless, there were some people who drank heavily; for example, one guy showed up whose pre-alcohol breathalyzer was 0.12.

**Tabakoff:**  One important thing I didn't see in the data is some attention to the recent history of alcohol abuse. You have average weekly consumption, you have consumption over the past year or so. How well did you know what they were doing the day before or the night before?

**Martin:**  I think I went too quickly over that. We actually asked them when they had their last drink and how much they drank. I made that into a single variable we regressed out which I just called "last drink." There was no correlation, either, in the time points. It ranged from 0.1 to negligible across the whole sample. That's not to say that for certain individuals it may not have been important, but across the whole sample it was negligible.