Good Curves (Fig 3)

Discusses Mellanby phen.

PB-234 035

ACUTE TOLERANCE TO BEHAVIORAL IMPAIRMENT BY ALCOHOL IN MODERATE AND HEAVY DRINKERS

System Development Corporation

PREPARED FOR

National Highway Traffic Safety Administration

June 1974

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DOT HS-801 160

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Contract No. DOT-HS-009-2-322

July 1974

Final Report

PREPARED FOR:
U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.
DOT HS 801 160

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
Acute Tolerance to Behavioral Impairment by Alcohol in Moderate and Heavy Drinkers

5. Report Date
June 1974

6. Performing Organization Code

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8. Performing Organization Report No.
TM(L)-4970/013/00

9. Performing Organization Name and Address
System Development Corporation
2500 Colorado Avenue
Santa Monica, California 90406

10. Work Unit No.

11. Contract or Grant No.
DOT HS-009-2-322

12. Sponsoring Agency Name and Address
National Highway Traffic Safety Administration
U.S. Department of Transportation
400 Seventh Street, S.W., Washington, D.C. 20590

13. Type of Report and Period Covered
Final 6/30/72 to 4/19/74

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The literature reports greater impairment effects of a given Blood Alcohol Concentration (BAC) during the rising than during the falling BAC periods. This may be termed acute tolerance to contrast it with chronic tolerance built up over a long period of regular drinking. Because of failure to control pertinent variable, prior studies have not established the reliability of the phenomenon or permitted quantitative estimates of the impairment at various BAC levels. In the design of the present experiment, specific attention was paid to obtaining BAC estimates that would be unaffected by differences between arterial and venous BAC levels, to applying techniques to control for practice effects, and to using rates of administration of alcohol that would be typical of normal drinking patterns. A total of 40 subjects were examined on five behavioral measures at approximately .02% BAC intervals on both the rising and falling BAC curves. Twenty subjects were moderate drinkers tested to a maximum of .10% BAC and 20 subjects were heavy drinkers tested to a maximum of .15% BAC.

Under these controlled conditions, for a given BAC, greater impairment was found during the rising BAC period than during the falling BAC period; this finding was consistent and statistically significant but is of little practical importance. Differences in impairment were equivalent to a change in BAC level of .01% to .02%. Performance differences due to past drinking practices (chronic tolerance) were far greater. It is of theoretical significance, however, that the degree of acute tolerance developed by chronic heavy drinkers was as great as or greater than that found for moderate drinkers, suggesting different mechanisms for acute and chronic tolerance.

17. Key Words
Alcohol Impairment and Driving
Mellanby Effect
Acute Alcohol Tolerance
Chronic Alcohol Tolerance

18. Distribution Statement
Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

19. Security Classif. (of this report)
Unclassified

20. Security Classif. (of this page)
Unclassified

21. No. of Pages
66

22. Price
$3.75-1.45

ACKNOWLEDGMENTS

The authors wish to gratefully acknowledge the assistance of others in the successful completion of this study. Dr. Fred Benjamin of the National Highway Traffic Safety Administration in his role as Contract Technical Manager provided valuable advice and guidance during the planning and conduct of the study and constructive comments on the preparation of this report.

Dr. Albert Ahumada, Department of Psychology, University of California, Irvine is due special recognition for his assistance in the development and execution of the statistical analysis program used to analyze the data.

Mr. Ed Lash and Mr. Isadore Wendel, who served as experimenters, were responsible for the actual conduct of the experiment including the administration of alcohol and behavioral tests, recording and manual processing of the data, and last but not least, maintaining rapport with the subjects and ensuring their cooperation even when highly inebriated. They performed these tasks with professional thoroughness while working extremely long hours on an irregular schedule.

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INTRODUCTION

Considerable literature exists devoted to studies of a form of acute alcohol tolerance known as the "Mellanby Effect." The purported phenomenon is named for E. Mellanby (1919) who first reported that the magnitude of behavioral impairment associated with a given blood alcohol concentration (BAC) is greater during a rising BAC than during a falling BAC. While the majority of experiments examining the issue have supported the existence of such a short term, rapidly developing tolerance effect, incomplete control of many possible biasing factors have left the reliability of the phenomenon and its magnitude in doubt.

Despite the limited knowledge regarding the effect, there has appeared the suggestion that this source of variability in skill performance at a given BAC could be used as a legal defense against an accusation of driving under the impairing influence of alcohol (Rabinowitch, 1955). The argument appears to rest upon the assumption that this source of variability is sufficiently great to render meaningless the establishment of a given BAC as the point at which impairment is sufficient to affect driving.

This study was undertaken to evaluate the reliability and magnitude of the Mellanby phenomenon with attention to issues most relevant in generalizing to persons accused of driving while under the influence of alcohol (DWI). Thus the subject population included both moderate and heavy drinkers, and special attention was given to administering the alcohol treatments at rates typical for the drinking population.

As Hurst and Bagley (1972), Harger (1963), and others have noted, many prior studies of the Mellanby effect have been inconclusive due to failure to provide adequate controls for possible confounding factors. For example, many studies have based their BAC estimates upon venous blood samples extracted from various body extremeties at the same time that performance measures were taken. Since venous blood alcohol levels derived from limb samples lag considerably in time in reaching equilibrium with blood alcohol concentrations obtained from the arteries or the brain during the rising BAC period, analysis of venous blood samples would inevitably lead to an underestimation of the true brain alcohol concentration during the rising BAC (Harger, 1963; Begg, Hill, and Nickolls, 1963). Thus a performance test taken during the rising BAC will exhibit greater impairment than during the falling BAC if the alcohol level is determined by venous sampling since the brain BAC is underestimated during the rising condition by the venous BAC. This source of confounding may be overcome by using sources other than venous blood samples to obtain BAC estimates. Suitable techniques for estimating brain BAC include analysis of arterial blood samples, fingertip capillary blood samples (Goldberg, 1943), or breath samples (Hurst and Bagley, 1972), since the lungs are in equilibrium with arterial blood and hence the brain.

Another confounding factor in past studies of the Mellanby phenomenon has been a failure to control adequately for practice effects. Typically, a subject is administered alcohol and his performance is examined at comparable BACs, first during the rising alcohol period and then again during the falling alcohol period. (cf. Mirsky, et al., 1941; Eggleton, 1941; Alha, 1951.) In these examples, the practice obtained during the rising BAC tests might be expected to bias the results obtained under the falling BAC conditions. Golberg (1943) and Hurst (1972) controlled for practice effects by having control placebo subjects who received the same time sequence of tests as the experimental subjects. The error scores of the control subjects for each time period were then subtracted from the scores of the experimental subjects. This technique is an adequate control except for any differential effects of practice which occur in the placebo state as compared with the alcohol state.

One factor of importance which has not been considered in past studies on the Mellanby effect is the influence of the rate of administration of the alcohol treatments. In nearly all prior studies, the rate of administration has been extremely rapid. Thus Goldberg (1943) administered doses of .63 to 1.42 grams alcohol per kilogram bodyweight (g.alc./kg.bw.) in ten minutes; Mirsky, et al; (1941), gave 1 g.alc./kg.bw. in five minutes, and Alha (1951), .5 to 1.25 g.alc./kg.bw. in 12 minutes

The difficulty with rapid rates of alcohol administration is the possibility that the greater rising curve impairment found in these studies is due to the rate of change in BAC, rather than any basic difference in performance on the rising versus the falling curve. Kalant, LeBlanc, and Gibbons (1971) suggest that acute tolerance takes time to develop and hence the more rapid the intake, the less time available for acute tolerance to develop at any given BAC. Obviously, when attempting to generalize from laboratory data to the significance of acute tolerance for impairment in persons arrested for DWI, it is necessary to administer the alcohol at rates typical for most drinkers. If the rate of administration affects the degree of impairment of behavior at a given BAC, comparisons of rising and falling BAC periods should be undertaken at similar rates of rising and falling BACs for the most meaningful comparison from a theoretical standpoint.

Moreover, from the empirical viewpoint of the relevance of this acute tolerance effect to the relative degree of impairment of persons arrested for DWI, it would be necessary to administer the alcohol at rates typical for most human drinkers. Observations in bars suggest that intakes greater than 3 to 4 drinks per hour is rarely found, even for heavy drinkers. This generalization is, of course, highly a function of the cultural areas surveyed.

Finally, except for the work of Goldberg (1943, 1966), few have examined whether acute tolerance varies as a function of prior drinking history. Since heavy drinking practices clearly produce a chronic alcohol tolerance, an examination of acute tolerance should sample persons with a range of drinking practices. Again, this is of considerable importance for persons arrested for DWI since they tend to be those with histories of heavy drinking.

This current examination of the Mellanby effect attempted to control for the factors discussed above. Forty subjects were tested—20 of whom were very heavy drinkers capable of reaching .15% BAC without discomfort and 20 were moderate drinkers who would have difficulty achieving a BAC greater than .10% without illness. Alcohol administration averaged .320 gr.alc./kg.bw. per hour for moderate drinkers, and .345 gr.alc./kg.bw. per hour for heavy drinkers.

To counterbalance for practice effects in the presence of alcohol, subjects were required to attend two drinking test sessions—once for testing on a rising BAC curve and once for testing on a falling BAC curve. Half the subjects were first tested on the rising BAC curve and then on the falling BAC curve on the second test day. The other half of the subjects received the treatments in the reverse order. Finally, the alcohol level was determined through use of a breath sampling gas chromatograph, a technique which samples a source of alcohol information in equilibrium with arterial blood alcohol levels.

Five behavioral performance measures were taken at various BAC points. These measures were: hand steadiness while standing and sitting; body sway in the lateral and anterior/posterior planes; and auditory signal detection while simultaneously executing a digit recall task.

METHOD

Subjects

Male subjects were recruited by referrals from the California State Unemployment Office, from advertisements in newspapers and from notices posted in the local Department of Motor Vehicles office. An initial screening interview of applicants removed those with possible health defects or histories of excessive past or current drug usage. The Oates and McCoy (1973) and Cahalan, Cisin, and Crossley (1969) questionnaires were administered to the remaining applicants and the results used to classify subjects into 2 arbitrary classifications as "heavy" or "moderate" drinkers. For the purposes of this study, these terms are used to designate persons believed capable of achieving without illness a BAC of .15% (heavy) or a BAC of .10% (moderate). Heavy drinkers were required to obtain a score of 23 or greater upon the Oates and McCoy (1973) scale as well as indicating in the interview a recent history of heavy drinking experience. Moderate drinkers were those who obtained less than 23* on the Oates and McCoy scale but were classified as at least "light" drinkers on the Cahalan, Cisin, and Crossley scale. All 20 subjects in the heavy group were classified by the Cahalan, et al., scale as "heavy" drinkers. Of the 20 subjects in the moderate group, the Cahalan, et al., scale classified 3 as "light," 10 as "moderate," and 7 as "heavy" drinkers.

The two groups were quite similar in age, income, weight, and marital status with a slightly higher educational level in the moderate group. For the moderate group, mean age was 30.9, mean education was 15.4, median income was $5,000, and mean weight 169. Comparable mean figures for the heavy drinkers was age 30.6, education 13.7, median income < $5,000, and weight 177.

Study participants were paid $1.65 an hour plus time and one-half for overtime over 8 hours with an additional $50 bonus for completion of the study.

Response Measures and Apparatus

Hand steadiness while standing was measured by the amount of time a metal stylus was in contact with the walls of a hole in a metal plate. The 1mm diameter stylus had a 5.17cm length t which was inserted halfway in a 6.4mm diameter hole.

The hole in the metal plate was adjusted to shoulder height for each subject. The task was performed with the subject facing the plate, his arm extended and one foot in front of the other. Each trial was 40 seconds in length and the error scores were the number of seconds the stylus contacted the metal plate.

Hand steadiness was similarly measured with an extended arm except that the subject was seated. For this measure, the hole in the metal plate was 3.9mm. Again, the measure was the number of seconds the stylus contacted the metal plate during a 40-second trial.

Body sway was measured by attaching 2 strings to a leather harness mounted at chest height on the subject and measuring the excursions of the strings. One string was attached to the subject's back and the other to his side. The strings were lightly weighted and passed over low friction pullies allowing easy movement. Movements of the pullies were sensed such that each 1/4 inch excursion of the strings and hence each 1/4 inch of body sway activated a counter. The string attached to the back measured sway in the anterior/posterior plane and the string attached to the side measured sway in the lateral plane.

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*Two of moderate subjects had scores of > 23 on this questionnaire but their interviews did not suggest recent experience at the .15 level.

Auditory signal detection under division of attention conditions was measured by requiring the subjects to detect a tone in random noise bursts presented to the left ear while simultaneously performing a digit recall task presented to the right ear. Every 10 seconds a 3-second burst of random noise was presented to the left ear. On half of the trials, a 1,000 Hertz tone of 1-second duration was presented at some random position in the noise burst with an intensity of 15 decibels below that of the random noise.* During the same 3 seconds, the right ear was presented with a set of 6 random digits at 1/2-second intervals. During the 7-second inter-trial interval, the subject was required to report the 6 digits in correct sequence and to state whether the tone was present. Each test sequence contained 100 trials and required almost 17 minutes to complete. The task was presented to the subject while he was seated in a sound isolation chamber wearing binaural earphones with input from a stereo tape recorder. The subject's responses were transmitted from the isolation chamber by intercom and were recorded by the experimenter.

Alcohol Treatment

Alcohol was administered in the form of mixed drinks containing 80 proof vodka and one of several carbonated mixes at the choice of the subject. Treatments were administered at hourly intervals with 15 minutes allocated for consumption. For the rising BAC experimental sessions, it was intended that the moderate and heavy drinkers should increase their BACs at the rate of .020% BAC per hour until they attained .10% BAC. The heavy drinkers were to continue beyond this point to .15% at the rate of .025% BAC per hour. To achieve this, subjects were administered .296 grams of alcohol per kilogram bodyweight (g.alc./kg.bw.) per hour until they achieved .10% BAC. Then the treatment rate was increased to .376 g.alc./kg.bw. per hour until .15% BAC. Actual doses administered varied slightly from these doses. Subjects' actual BACs were monitored and if the BAC differed by more than .01% BAC from the desired BAC, the next hourly dose was increased or decreased by 4.67 grams of alcohol.

Alcohol treatments during the rising BAC period for subsequent falling BAC measurement sessions differed from the above. It was intended that the moderate

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*In this experiment, the dual task lacked the sensitivity to the effects of alcohol found in other studies such as Moskowitz and DePry (1968), Moskowitz (1973). Therefore, for some subjects, the signal to noise ratio was changed to -16 db or -17 db, but these changes failed to affect the task's sensitivity to alcohol.

drinkers should increase their BAC at the rate of .025% per hour and an hourly dose was administered of .35 g.alc./kg.bw. ± 4.67 grams.

During the rising phase of the falling BAC measurement session for the heavy drinkers, the desired rising rate was .038% BAC per hour for which a dose of .414 g.alc./kg.b.w. ± 4.67 grams of alcohol was administered per hour. The drinking rates for the rising phase on the falling BAC measurement session were selected so as to commence the actual performance tests at approximately the same time as they were performed on the rising BAC measurement sessions. This was done to control for possible diurnal fatigue effects. Subjects' BACs were measured by a breath-sampling gas chromatograph with a 3-place digital readout.

Training

Subjects attended a training session of approximately four hours duration. They received training on the hand steadiness and body sway tests but the majority of the time was occupied with training on the divided attention (DA) signal detection task. Subjects received approximately two hours of training on this task until they achieved at least a 70% level of correct performance. If they were unable to meet this criterion, they were dropped as subjects.

Subjects were then administered a single alcohol dose of .296 g.alc./kg.bw. The alcohol was followed by two more hours of experience on all tests. Thus all subjects had test practice under the effects of the drug prior to the experimental sessions. Subjects unable to achieve at least 60% correct response on the DA task under this small alcohol dose were eliminated as potential subjects.

Procedure

On the two experimental days, subjects came to the laboratory at 8 a.m. without having eaten since the preceding evening. After being checked to ensure a zero BAC, subjects were given a complete set of experimental trials as a warm-up. Following this, the day's activities diverged for the various groups.

On the days when the tests were to be administered on the rising BAC curve, subjects had a large breakfast at 8:30 a.m. followed by two hours of free time for reading or watching TV. At 11:00 a.m. they received a light lunch followed by more free time until 11:45 a.m. when they received their first drink. Following 15 minutes allowed for drinking and five minutes of free time, the hand steadiness and body sway tests were given. This required approximately 10 minutes. After a breath alcohol test, the divided attention test was given in about 17 minutes followed by another breath test. The sequence of drinking, 5-minutes rest, motor tests, breath analysis, divided attention test, breath analysis took almost exactly one hour. This sequence was repeated every hour for 5 hours for the moderate drinkers and 7 hours for the heavy drinkers. This permitted peak BACs of .10% and .15% for the moderate and heavy groups, respectively. After testing performance was completed, the subjects were given dinner and kept in the laboratory until their BACs were below .04% when they were driven to their homes.

For the test days when the testing was done on the falling BAC curve, the procedure was as follows: Subjects were again picked up at 8 a.m., examined for the presence of alcohol, given a warm-up test series and then their first drink at 8:35 a.m., followed by a light breakfast at 8:50 a.m. After this, the subjects' time was free for reading or TV watching, except for 15-minute drinking intervals every hour until 12 noon. The four drinking sets were generally sufficient, given the appropriate dosages, to achieve .10% BAC for the moderates and .15% BAC for the heavy drinkers, although a few subjects required a fifth drink. After the last drink, a one-hour wait ensued, followed by the beginning of testing at about 1 p.m. The 10-minute motor tests were administered followed by 5 minutes for breath testing, followed by 17 minutes of DA testing, followed by another breath test, followed by a free period. During the first free period, lunch was served. This testing sequence was not repeated precisely on the hour since it was desired to test the subjects at every .02% BAC on the falling phase and the testing was slowed if the falling rate was slower than .02% BAC per hour. For the majority of moderate subjects, testing was completed by 7 p.m. but for the heavy drinkers testing lasted as late as 10 p.m.

As noted above, this schedule of drinking and testing was designed to permit performance testing to occur at the same time of day for both rising and falling BAC groups to control for possible diurnal rhythm effects.

RESULTS AND DISCUSSION

Figures 1-3 present the mean BACs as a function of time for the heavy and moderate drinkers. Figure 1 summarizes the data for the rising BAC phase on the rising BAC test days. The number at each point represents the number of subjects included in that data point. Figures 2 and 3 represent the rising and falling BAC phases for data gathered on the falling BAC test days. Except for the end points of the curves where number of subjects is changing rapidly, the data are notably linear in rate of change. This normally is found for the falling BAC curve as the rate of metabolism for individuals is typically quite uniform over time. The linearity of the rising BAC phase is a result of the pattern of alcohol consumption in this experiment.

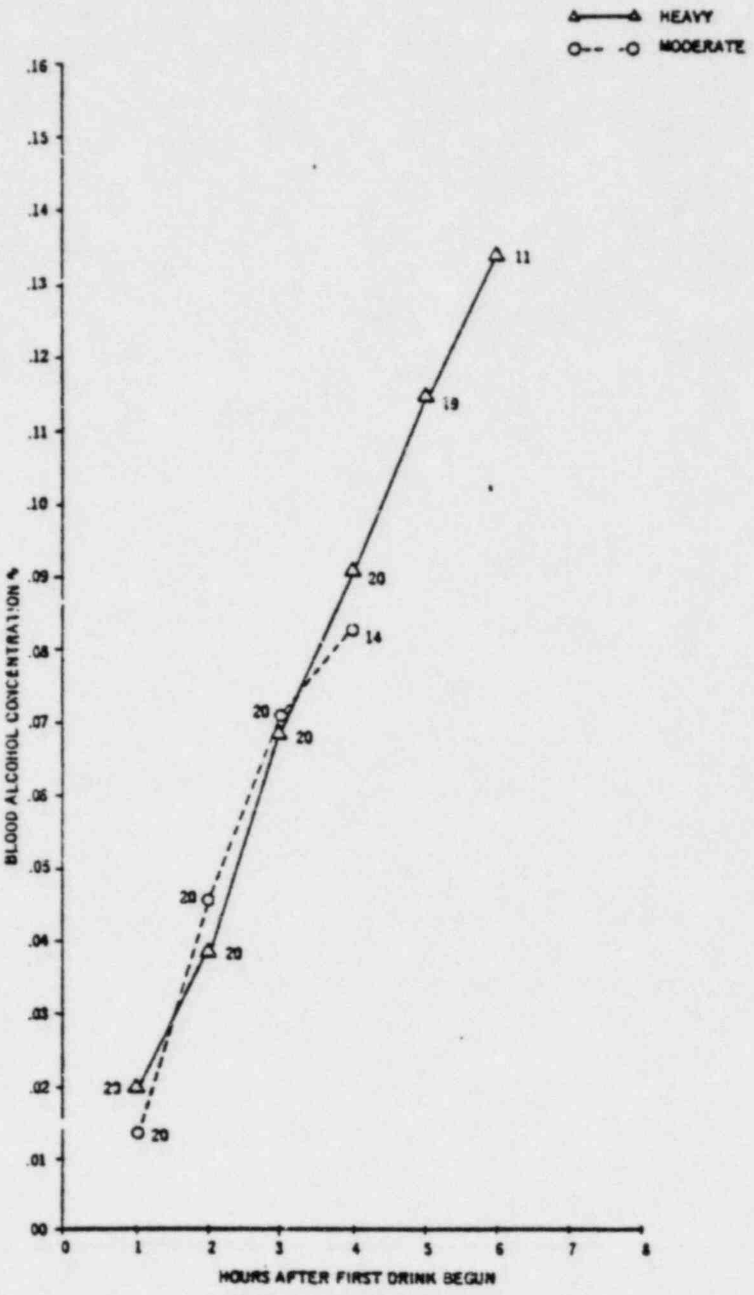


Figure 1. Mean rising BACs as a function of time on rising BAC test days

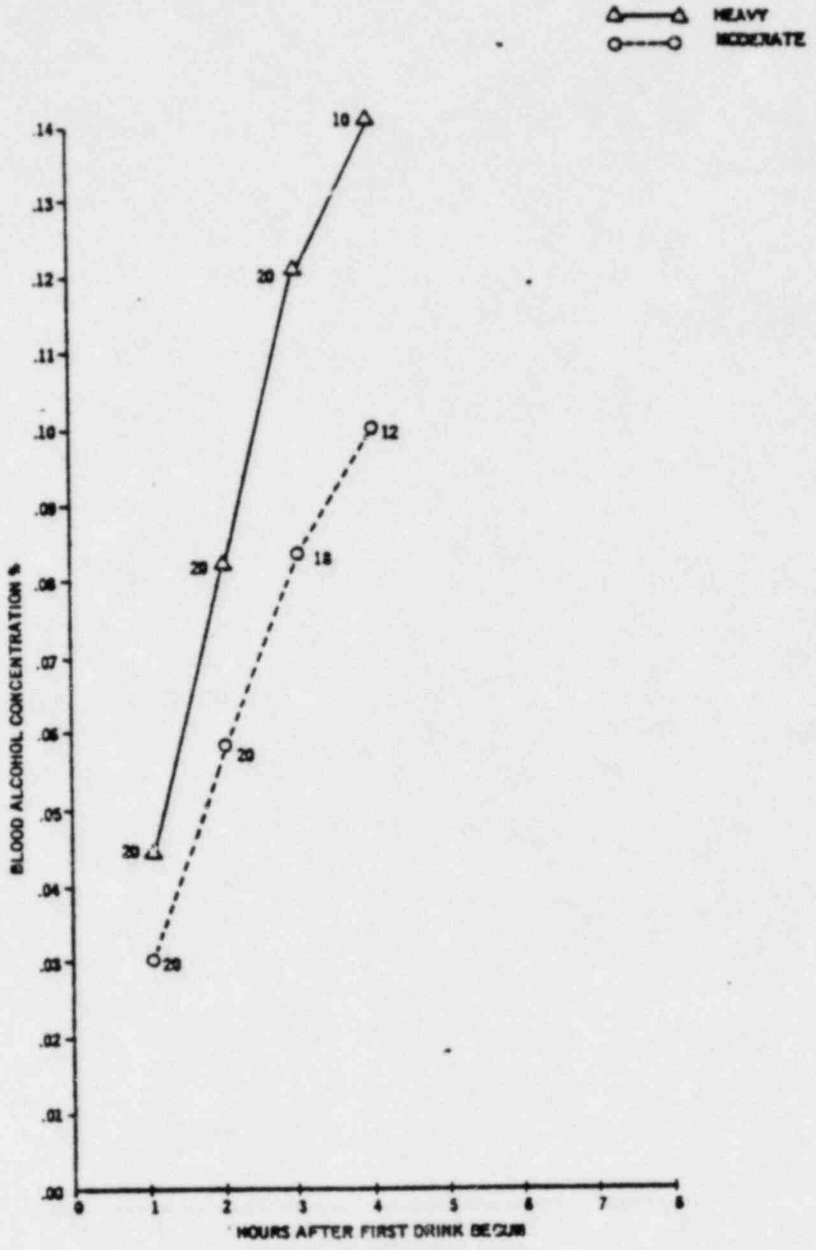


Figure 2. Mean rising BACs as a function of time on falling BAC test days

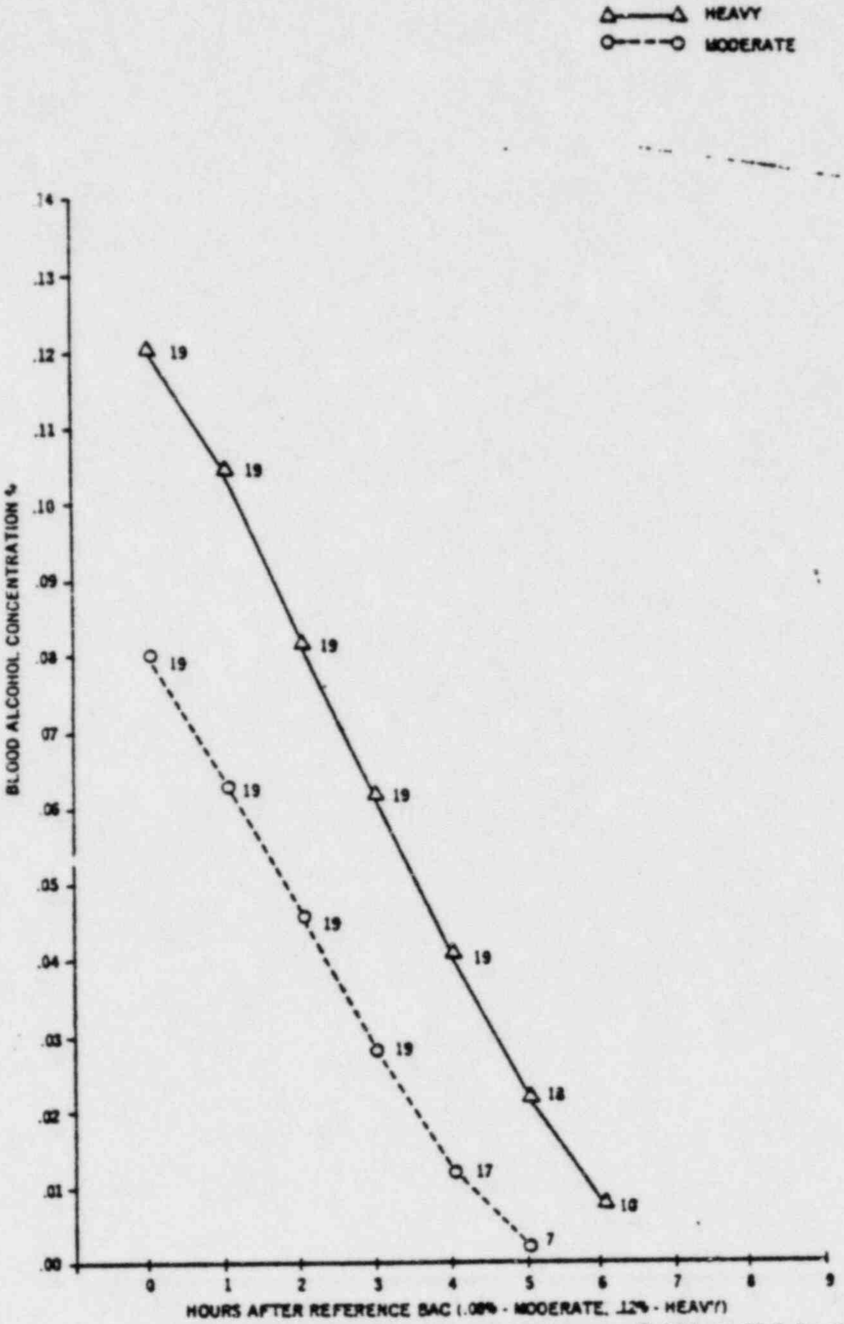


Figure 3. Mean falling BACs as a function of time on falling BAC test days

One of the objectives of this study was to test for performance changes during roughly equivalent rates of changes in BAC on the rising and falling phases. BAC rose approximately .023% per hour for the moderate and .024% for the heavy drinkers during the rising phase on the rising BAC test day. Similarly, BAC fell approximately .020% per hour for heavy drinkers and .017% per hour for the moderate drinkers on the falling BAC test day. Thus the experimental design objective of equivalent rising and falling BAC rates is approached much more closely in this study than in prior Mellanby research.

The greater rate of disappearance of alcohol in the heavy drinkers was also manifest in a correlation (Pearson) of .52 between a subjects' scores on the Oates-McCoy Questionnaire (1972) and their alcohol removal rate. Clearly, frequent experience with alcohol affects the rate at which subjects dispose of alcohol, a finding mentioned frequently in the literature. (cf. Wallgren and Barry, 1970.)

The rate of increase in BAC was greater during the rising phase on the falling BAC test days. This was necessary to permit testing to occur at the same time of day to offset possible diurnal effect. The heavy drinkers increased their BACs at .039% per hour and moderate drinkers at .029% per hour. These differences are a direct result of the experimental procedure adopted.

Figures 4 and 5 present the mean performance scores for all subjects on each of the 5 behavioral response variables under conditions of both rising and falling BAC. The figures show the mean performance as a function of BAC from .02% to .11% BAC in increments of .01% plus the pre-test performance. Since measures could rarely be taken at exactly .01% BAC points, the points for mean curves were taken by linear extrapolation from individual curves created for each subject on each run by plotting the actual data points obtained for each subject. The mean curves were limited to the range .02% - .11% to ensure sufficient data points.

Tables 1 through 5 present the statistical analysis on the response measures presented in Figures 4 and 5. The analysis was performed using the X63 (now 11V) Biomedical statistical program of the UCLA Health Sciences Computing Facility (Dixon, 1973). This statistical program is a repeated-measures multivariate analysis of variance based on a linear hypothesis model. The analysis on each response variable was performed three times: once for the entire BAC curve and once each for comparisons at the .05% and .10% BAC. The data points utilized for the statistical analysis were generated by fitting each individual subject's performance curves to an equation of the form $Y = A + Bx + Cx^2$, by a least squares technique. This was necessary to obtain performance scores at common BAC points for all subjects.

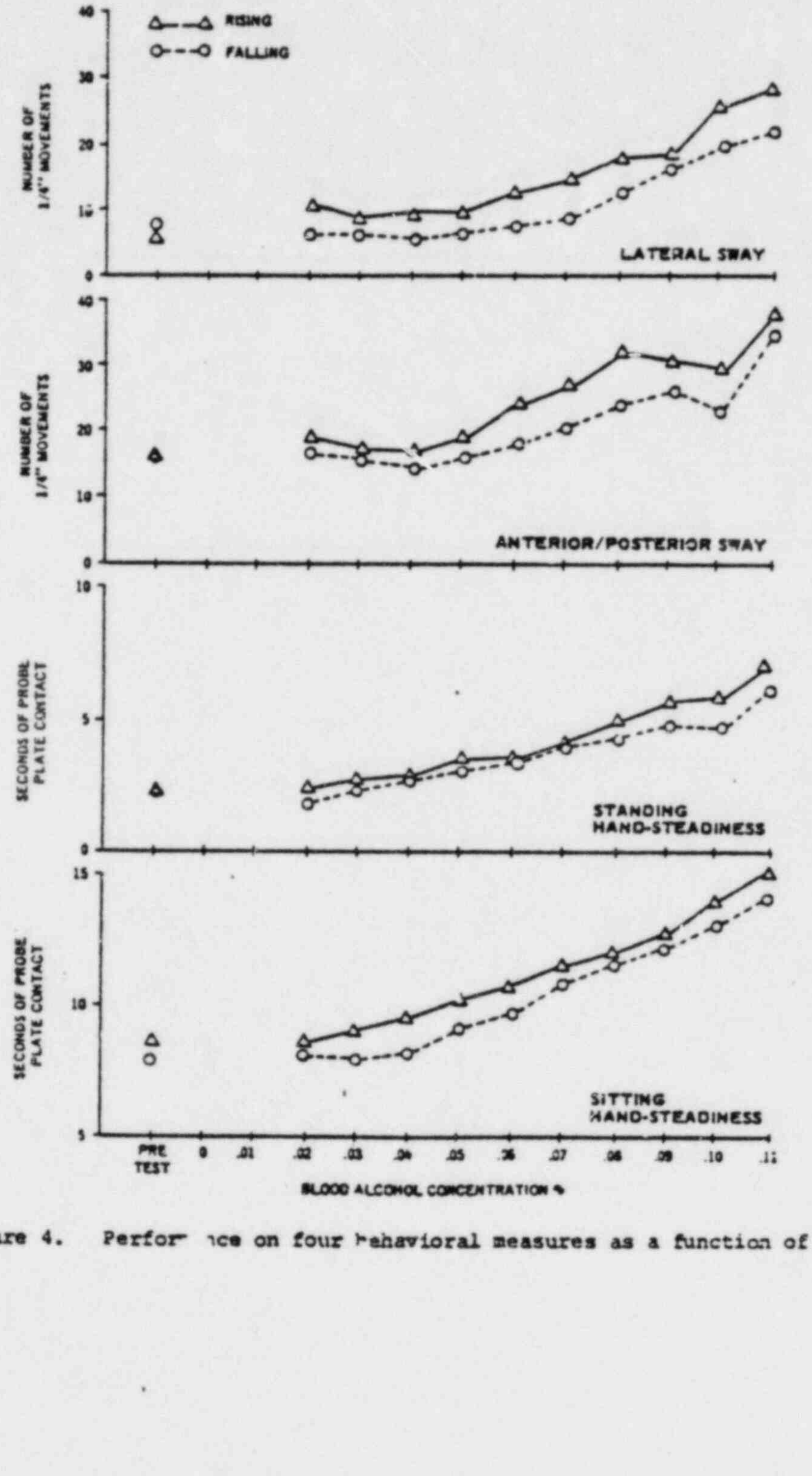


Figure 4. Performance on four behavioral measures as a function of BAC

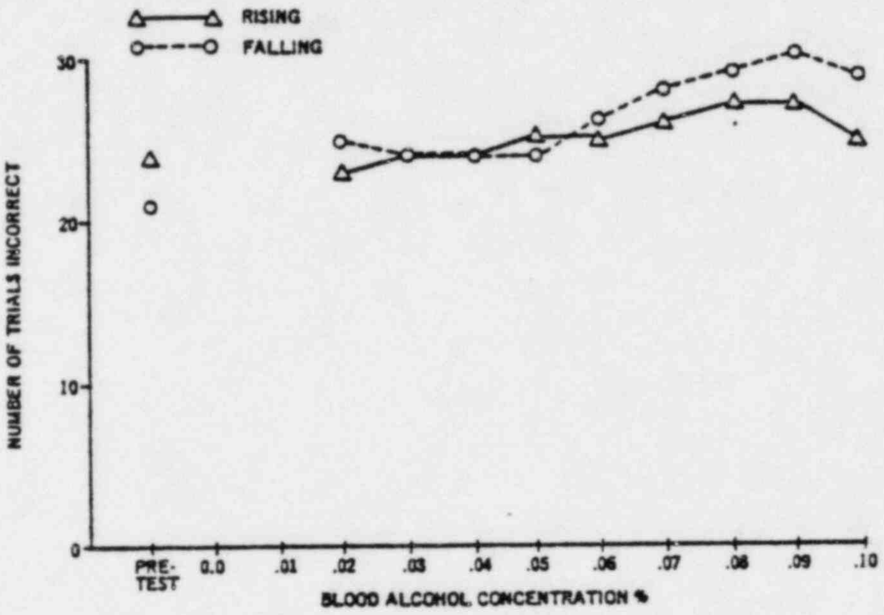


Figure 5. Performance on the auditory divided attention task as a function of BAC

Table 1. Lateral Sway Analysis of Variance for BAC of .05%, BAC of .10% and Total Curve

Source	.05% BAC F, dF = 1/36	10% BAC F, dF = 1/36	Total Curve F, dF = 3/34
Heavy vs. Moderate Drinkers (A)	3.506^{+}	3.388^{+}	2.306^{+}
Falling First vs. Rising First (B)	0.035	1.414	0.966
Falling Curve vs. Rising Curve (C)	13 399**	0.376	5.576**
AxB	3.482^{+}	0.225	3.821*
AxC	2.221	1.479	1.604
BxC	0.077	2.402	1.633
AxBxC	2.371	2.594	2.077

Table 2. Anterior/Posterior Sway Analysis of Variance for BAC of .05%, BAC of .10%, and Total Curve

Source	.05% BAC F, dF = 1/36	.10% BAC F, dF = 1/36	Total Curve F, dF = 3/34
Heavy vs. Moderate Drinkers (A)	6.204*	4.741*	2,761*
Falling First vs. Rising First (B)	1.100	4.745*	1.704
Falling Curve vs. Rising Curve (C)	5.253*	4.236*	3.765*
AxB	2.969^{+}	0.258	1.191
AxC	1.171	0.825	1.612
BxC	0.575	5.926*	2.341^{+}
AxBxC	1.438	3.568^{+}	1.528

Table 3. Hand Steadiness (Standing) Analysis of Variance for BAC of .05%, BAC of .10%, and Total Curve

Source	.05% BAC F, dF = 1/36	.10% BAC F, dF = 1/36	Total Curve F, dF = 3/34
Heavy vs. Moderate Drinkers (A)	6.392*	5.583*	2.246
Falling First vs. Rising First (B)	3.705^{+}	10.665**	3.467*
Falling Curve vs. Rising Curve (C)	1.404	0.069	4.356*
AxB	2.761	2.600	1.483
AxC	5.148*	1.418	2.480^{+}
BxC	1.328	0.014	0.704
AxBxC	0.988	0.437	0.994

$+ = p < .10$; $^{*} = p < .05$; $^{**} = p < .01$

Table 4. Hand Steadiness (Sitting) Analysis of Variance for BAC of .05%, BAC of .10%, and Total Curve

Source	.05% BAC F, dF = 1/36	.10% BAC F, dF = 1/36	Total Curve F, dF = 3/34
Heavy vs. Moderate Drinkers (A)	0.035	1.125	1.118
Falling First vs. Rising First (B)	2.361	4.374*	3.304*
Falling Curve vs. Rising Curve (C)	1.418	2.123	2.389+
AxB	5.754*	2.850	2.140
AxC	2.195	0.553	1.663
BxC	0.001	1.992	1.543
AxBxC	0.282	2.291	0.804

Table 5. Divided Attention Analysis of Variance (Trials Correct) for BAC of .05%, BAC of .10%, and Total Curve

Source	.05% BAC F, df = 1/36	.10% BAC F, dF = 1/36	Total Curve F, dF = 3/4
Heavy vs. Moderate Drinkers (A)	0.481	2.447	2.436+
Falling First vs. Rising First (B)	0.990	0.506	0.614
Falling Curve vs. Rising Curve (C)	0.407	3.144+	1.532
AxB	1.046	0.797	0.378
AxC	0.218	0.644	0.079
BxC	1.671	2.850	2.905*
AxBxC	0.423	0.205	1.668

+ = $p < .10$; * = $p < .05$

As discussed previously, the experimental design is a repeated measures 2 x 2 x 2 factorial with the three dimensions being drinking habits (moderate versus heavy drinkers), treatments (falling versus rising BAC), and sequence (falling BAC first versus rising BAC first). Since the 20 heavy and 20 moderate drinkers were tested twice, a total of 80 curves were obtained of performance versus BAC.

The two top curves in Figure 4 present the mean performance curves for lateral and anterior/posterior sway under conditions of rising and falling BACs. The curves clearly exhibit a greater degree of behavioral impairment under conditions of a rising BAC than for a falling BAC. Tables 1 and 2 indicate this difference to be statistically significant.

The two bottom curves in Figure 4 present the mean performance curves for the two measures of hand steadiness (subject standing and subject sitting) for both rising and falling BACs. Both figures suggest a slightly higher degree of impairment during a rising BAC, with somewhat greater differences between rising and falling BACs found for the sitting measure. However, Table 4 indicates that the hand steadiness while sitting measure is statistically signigicant only at the $p < .10$ level. Clearly, all four measures of motor control discussed above demonstrate a sensitivity to alcohol effect and, moreover, three of the four show a differential sensitivity as a function of the rising and falling blood alcohol conditions.

The results, therefore, are in conformity with the findings of Goldberg (1943) bor body sway and Hurst and Bagley (1972) and Myrstan and Goldberg (1971) for hand steadiness. However, the degree of greater impairment for rising curve appears to be considerably smaller than that found in these studies. The average difference for the rising and falling curves between .02% and .09% BAC were obtained and the percent advantage for the falling curve in respect to the rising curve was computed. The advantage for the falling curve was 25% for lateral sway, 17% for anterior/posterior sway, 8% for standing hand steadiness and 8% for the sitting hand steadiness. Overall, the mean difference was only 14%. Another way of expressing the effect of the advantage of this acute tolerance is to note by reference to the curves that the difference in performance represented by the Mellanby effect is equal to the change in performance produced by a change of .01% to .02% BAC. Clearly, the influence of the acute tolerance variable is less than found in most studies which have used these same response variables. Since this experiment differed in many aspects from the studies reviewed in the introduction, it is not possible to identify the variable or variables which account for the greatly reduced Mellanby effect found here. That obviously will require additional experiments which systematically manipulate each variable by itself. Perhaps the prime candidate for such studies is the influence of the rate of administration which previously has been reported as correlated with the degree of impairment, (cf. Kalant, LeBlanc and Gibbins 1971).

The fifth response variable was the divided attention (DA) test which demonstrated little sensitivity to alcohol as can be seen in Figure 5. Moreover, the DA test was equally insensitive to the influence of the rising and falling BAC curves as shown by Table 5. Thus, the average performance difference between the rising and falling curve was less than 4%. However, the lack of an acute tolerance effect on this test has little meaning since the test was insensitive. This is in contrast to results found in studies by Moskowitz and DePry (1968) and Moskowitz (1973) using the same measure and in similar studies of sensory performance under divided attention conditions by Hamilton and Copeman (1970) and Von Wright and Mikkonen (1970). It has tentatively been concluded that the extensive training experience and frequent repetitive testing served to produce a situation where, for the majority of subjects, the task was no longer one requiring division of attention or serial processing of information. As a task which apparently could be processed in parallel, it demonstrates little sensitivity to alcohol.

The two component sub-tasks which comprise the divided attention test (digit recall task and signal detection task) were examined separately. Graphical display of the two sub-tasks exhibited the same insensitivity to the effects of alcohol as shown by the combined task. Moreover, the statistical analysis for the sub-tasks failed to show any significant sensitivity to the effects of the rising and falling BAC curves as shown in Tables 6 and 7. Since the divided attention task, either as a whole or in parts, failed to exhibit sensitivity to the effects of alcohol, it scarcely can be a useful measure here for examining the differential influence of the rising and falling BAC curves and will be discussed no further. Subsequent analysis will be restricted to the four response measures found in this experimental situation to be sensitive to alcohol.

The design of this study differed from prior human studies in the slow rate of administration of the alcohol. Whereas, in most studies, the rising curve was complete within 1 to 1-1/2 hours after consumption of the alcohol, the rising alcohol curve in this study represents a period of some 4 to 5 hours.

It is perhaps due to the nature of the prior studies' alcohol administration procedures that Jellinek (1960) suggested that "short-range accommodation" occurs within 30 to 60 minutes. If this were true, a Mellanby effect would be expected during the first 30-60 minutes after alcohol is ingested when performance would be excessively degraded until short-range accommodation is complete.

It then follows that there should be no difference in this study between the falling and rising curves at the .03% BAC point and higher. For the falling curve, the subjects have been under the influence of alcohol for at least 4 hours and should be fully developed to their acute tolerance level. On the rising curve, the subjects will have required a minimum of an hour at least to reach .03% BAC, and any higher level will have required considerably

Table 6. Divided Attention Task Analysis of Variance for Tone Detections for BAC of .05%, BAC of .10%, and Total Curve

Scource	.05% BAC F, dF = 1/36	.10% BAC F, dF = 1/36	Total Curve F, dF = 3/4
Heavy vs. Moderate Drinkers (A)	0.061	1.422	1.915
Falling First vs. Rising First (B)	0.388	0.499	0.170
Falling Curve vs. Rising Curve (C)	0.114	1.311	1.090
AxB	0.214	0.460	0.709
AxC	0.323	0.183	0.128
BxC	1.436	0.115	1.698
AxBxC	0.069	0.041	1.181

Table 7. Divided Attention Task Analysis of Variance for Digits Correct for BAC of .05%, BAC of .10%, and Total Curve

Source	.05% BAC F, dF = 1/36	.10% BAC F, dF = 1/36	Total Curve F, dF = 3/34
Heavy vs. Moderate Drinkers (A)	0.806	1.249	0.634
Falling First vs. Rising First (B)	1.305	1.230	0.465
Falling Curve vs. Rising Curve (C)	0.510	3.911^{+}	2.370^{+}
AxB	0.345	0.001	0.970
AxC	0.045	0.057	0.023
BxC	0.148	0.400	0.656
AxBxC	5.541*	9.225**	4.493**

+ = $p < .10$; * = $p < .05$; ** = $p < .01$

longer. Therefore, if Jellink were correct, there should be no difference between the rising and falling curves above .03% BAC, which is contrary to what an examination of Figure 4 reveals. Thus, rather than the Mellanby effect being a matter of rapid acute tolerance within an hour, the phenomenon represents an influence for the entire period of the rising and falling curves--at least in this study. Jellinek's view appears to suggest that the phenomena is something akin to a habituation of the subject to the presence of alcohol in the system. Under that view, the accommodation would occur at a time independent of the rising curve time when the rising curve time was greater than the time necessary for accommodation.

From the view of Jellinek's proposed short-term accommodation, it would be anticipated that the greatest difference would occur at the earliest time of entry of alcohol into the body, i.e., at the lower BACs. Again the present data fail to support this view since the smallest differences are found at the lower BACs and there is a general tendency for the differences between the two curves to be greater at the higher BACs which occurred 4 to 5 hours after drinking was initiated. There is nothing in this experiment which would suggest why the difference between the rising and falling BAC curves should differ throughout the entire BAC range examined nor why there appears a small trend towards greater effect at higher BAC.

One matter of considerable interest is the rate of change of behavioral impairment as a function of change in BAC. It is clear on both the rising and falling BAC curves that for the higher BAC levels there is an increasing amount of impairment for each equal change in BAC level. In our study, this resulted in large quadratic components in the equations describing changes in behavioral impairment as a function of BAC. This is, of course, analagous to the finding of Goldberg (1943) of a logarithmic relationship between degree of impairment and BAC level.

The use of samples drawn from two populations representing different drinking practices permits this study to examine the issue of chronic or long-term tolerance. The criteria for selection for the heavy drinker group suggest that the group represents persons who frequently consume large quantities of alcohol and would be expected to exhibit chronic tolerance, a well established phenomonen associated with frequent alcohol consumption.

Figure 6 compares the heavy and moderate drinking groups in their performance over the BAC curve for the 4 response measures found to be sensitive to alcohol. The curves clearly suggest that chronic tolerance is a factor producing a greater difference in impairment than acute tolerance. Whereas, for the four response variables, the average saving associated with the falling curve was 14%, the average saving associated with chronic heavy

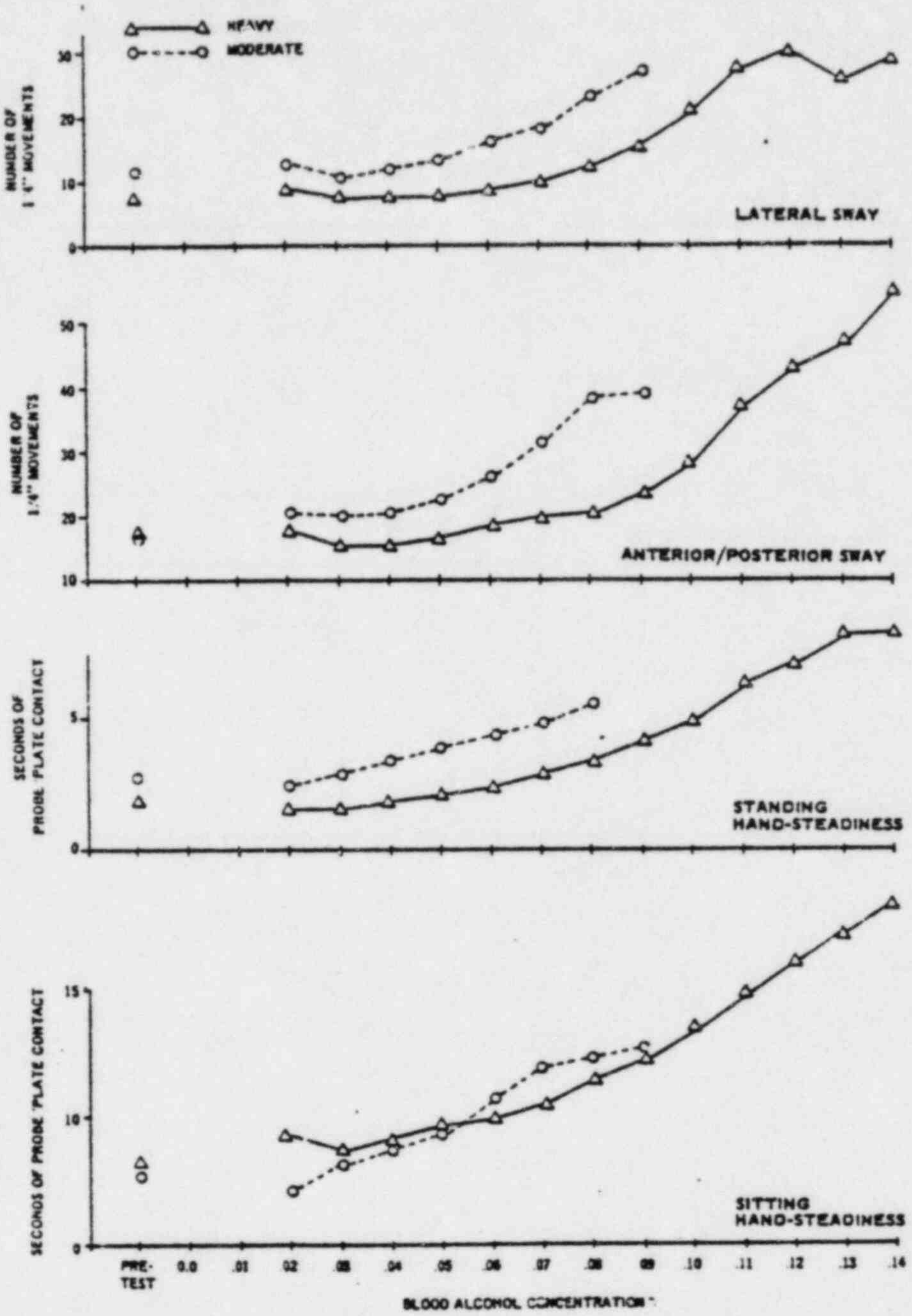


Figure 6. Performance of heavy and moderate drinkers as a function of BAC

drinking is .28% Tables 1 through 4 indicate that the difference between the heavy and moderate drinkers was statistically significant for anterior/posterior sway and hand steadiness standing, marginally significant ($p < .10$ level) for lateral sway and non-significant only for the hand steadiness sitting. It should be realized that the comparisons between heavy and moderate drinkers are between-subject comparisons which involve a greater likelihood of variability than the statistical analysis for the rising and falling curves which were within-subject analyses.

These results are in agreement with the widespread literature on chronic use of alcohol which has demonstrated that frequency of drinking is positively correlated with resistance to alcohol impairment of both behavioral and physiological measures. (cf. Goldberg, 1943; Kalant, LeBlank and Gibbonc, 1971). Studies reported in the literature have demonstrated that this is a true physiological "tissue" tolerance, not merely a function of experience with the specific task used as the response measure.

An issue of interest is the relationship between acute tolerance and past drinking experience. Figures 7 thru 10 present the rising and falling BAC curves on four response measures for the heavy drinkers and for the moderate drinkers separately. Examination of the difference between rising and falling curves for the heavy and moderate drinkers on the same response measure indicates that the development of acute tolerance in the heavy drinker is equal or greater than the social drinkers. Thus the chronic tolerance demonstrated for the heavy drinkers in Figure 6 has not insulated the heavy drinkers from the acute tolerance or Mellanby effect as demonstrated in Figures 7 thru 10.

The relationship between acute and chronic tolerance is considered statistically in the interaction terms between the rising versus falling BAC variable and the heavy versus moderate drinkers variable, the A X C interaction. Although all figures suggest greater acute tolerance effects in the heavy drinkers, this enhanced Mellanby effect in the heavy drinker reaches statistical significance only in the comparison for the hand steadiness while standing measure.

The results of this aspect of the study are in conflict with the suggestion offered by Jellinek (1960) that chronic heavy drinkers would be expected to show less acute tolerance and specifically a smaller Mellanby effect than moderate drinkers. This suggestion was based on the belief that the chronic tolerance induced by heavy drinker would have protected the drinker from some of the impairing effects of alcohol from the very start of the drinking session. The results herein obtained conform more closely with the expectations of the theory of tolerance developed by LeBlanc (1972) and Kalant, LeBlanc, and

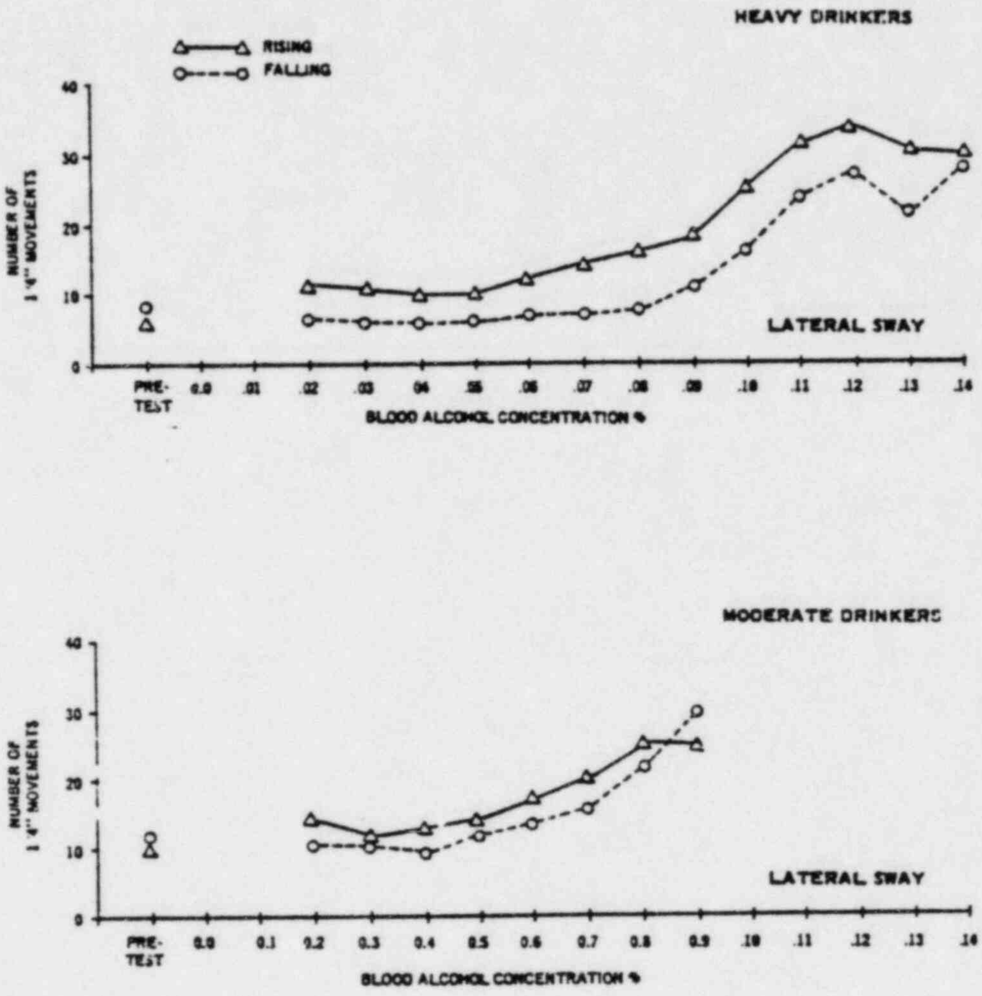


Figure 7. Rising and falling BAC performance of heavy and moderate drinkers on Lateral Sway

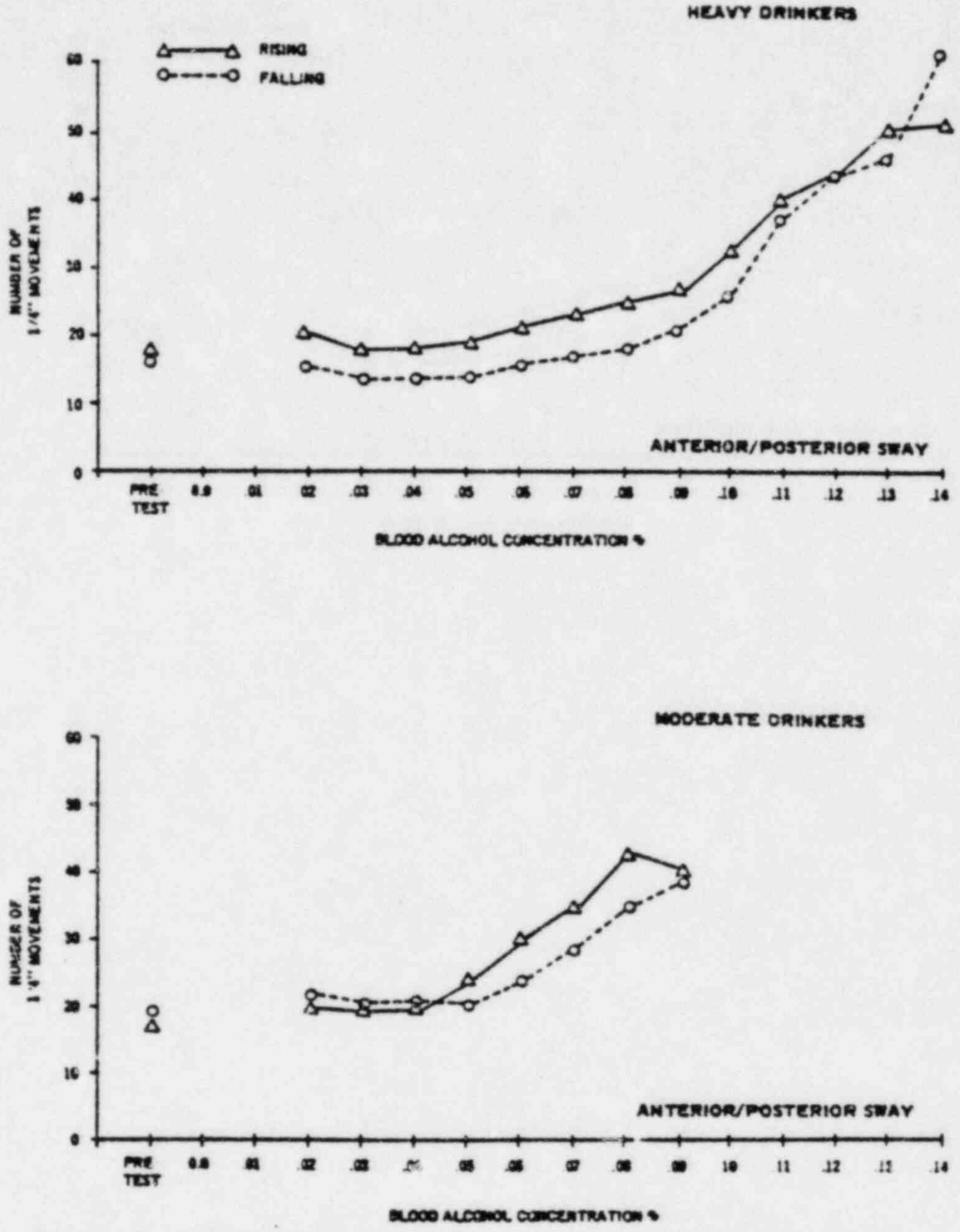


Figure 8. Rising and falling BAC performance of heavy and moderate drinkers on Anterior/Posterior Sway

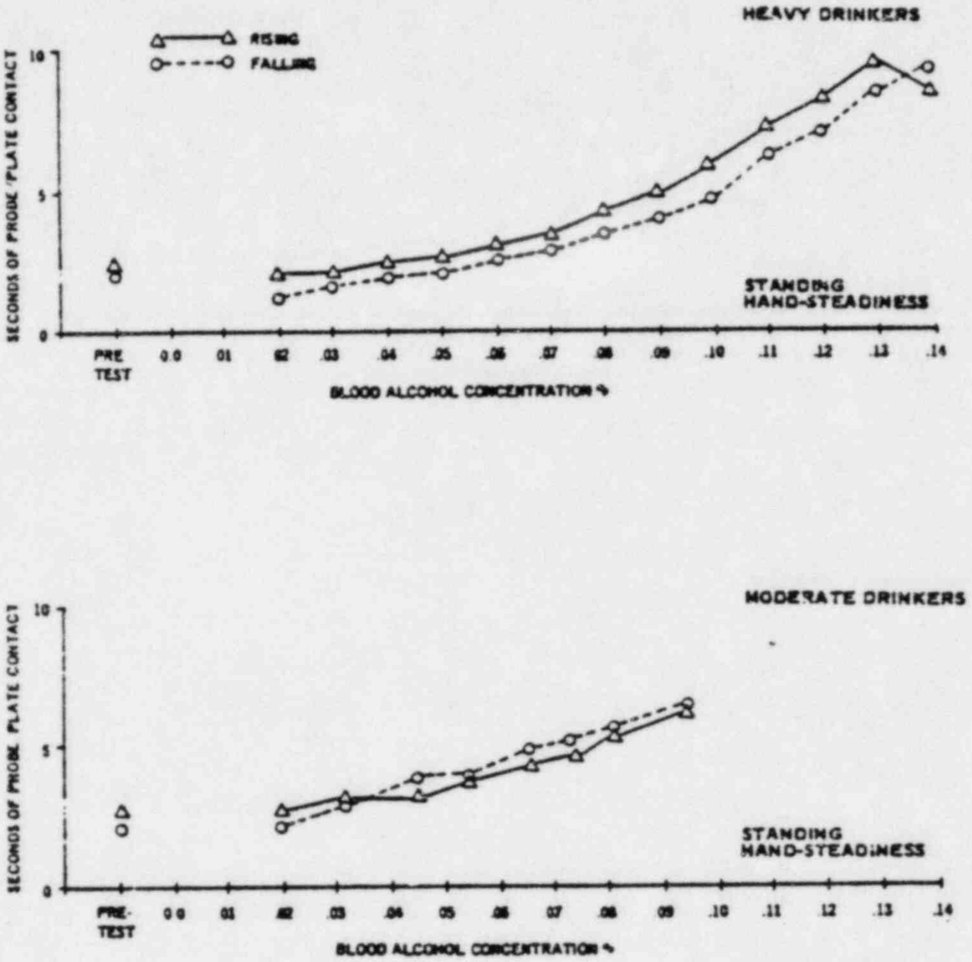
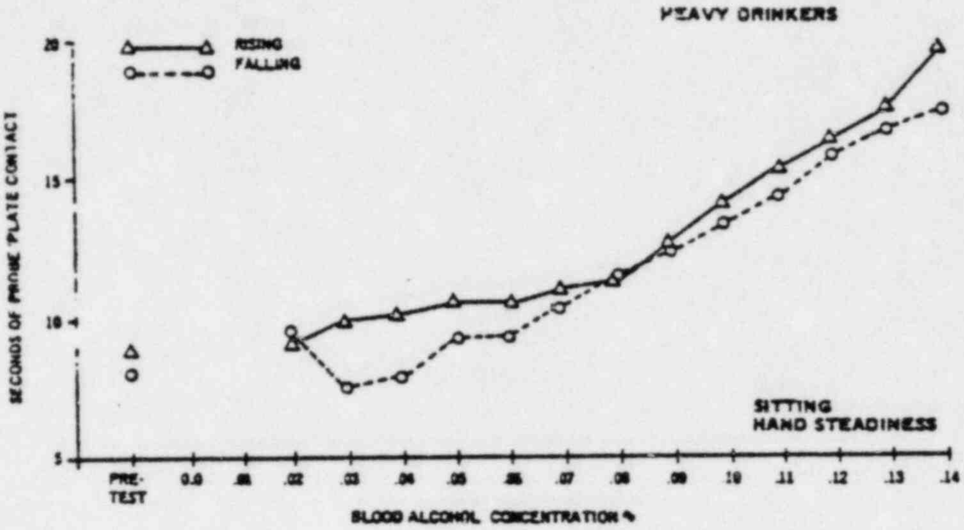


Figure 9. Rising and falling BAC performance of heavy and moderate drinkers on Standing Hand Steadiness



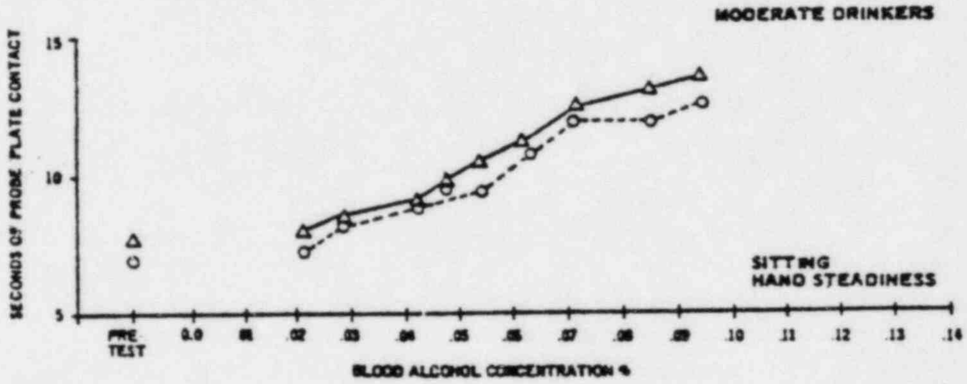


Figure 10. Rising and falling BAC performance of heavy and moderate drinkers on Sitting Hand Steadiness

Gibbins (1971). They propose that the result of the development of tolerance by heavy chronic drinking is a change in the rate and degree of final amount of acute tolerance exhibited at each drinking session, in comparison with that shown by a naive or moderate drinker. Thus both moderate and heavy drinkers would begin to exhibit behavioral impairment at approximately the same threshold level in the rising BAC curve. However, the rate of increase in impairment for the heavy drinker would be slower and reach a lower level at a given BAC level than for a moderate drinker. While there are conflicting data for this theory [c.f., Moskowitz and Wapner (1964) where chronically experienced rats showed tolerance at the initial test point], these data apparently support the above theoretical view.

Figure 11 illustrates the influence of the third dimension of the experimental design, the sequence effect. The figure contrasts the performance curves for the group which received the falling BAC curve first with the group receiving the rising BAC curve first. Clearly, in all displayed response measures, the group experiencing the rising-falling sequence exhibited less impairment under alcohol than those experiencing the falling-rising sequence. The size of the sequence effect averaged 21% advantage for the rising-falling group, a considerably greater effect than that found for the Mellanby effect.

Examination of Tables 1 through 4 indicates the sequence effects differences were significant for hand steadiness while standing and for hand steadiness while sitting and insignificant for the sway measures, except at the .10% BAC for the anterior/posterior sway. Again, it should be noted that the statistical analysis here is for a between-subjects analysis which includes more elements of variability than the within-subjects analysis of the rising-falling BAC curves. Clearly, the sequence effect is of considerable significance but neither the literature nor the authors have suggestions as to the cause of this sequence effect.

Although not included in the statistical analysis, it was decided to examine possible practice effect as exhibited by differences between sessions 1 and 2. Figure 12 presents the mean performance curves on the four response measures for the first versus second session. The small differences exhibited in the curves are reflected in an average difference of less than 4%, extremely small in respect to any other examined variable. Clearly, the training sessions served to remove any significant subsequent learning effects.

CONCLUSION

This study provides further support for the existence of that form of acute alcohol tolerance known as the Mellanby effect, which is exhibited as a differential behavioral impairment at the same BAC levels for rising

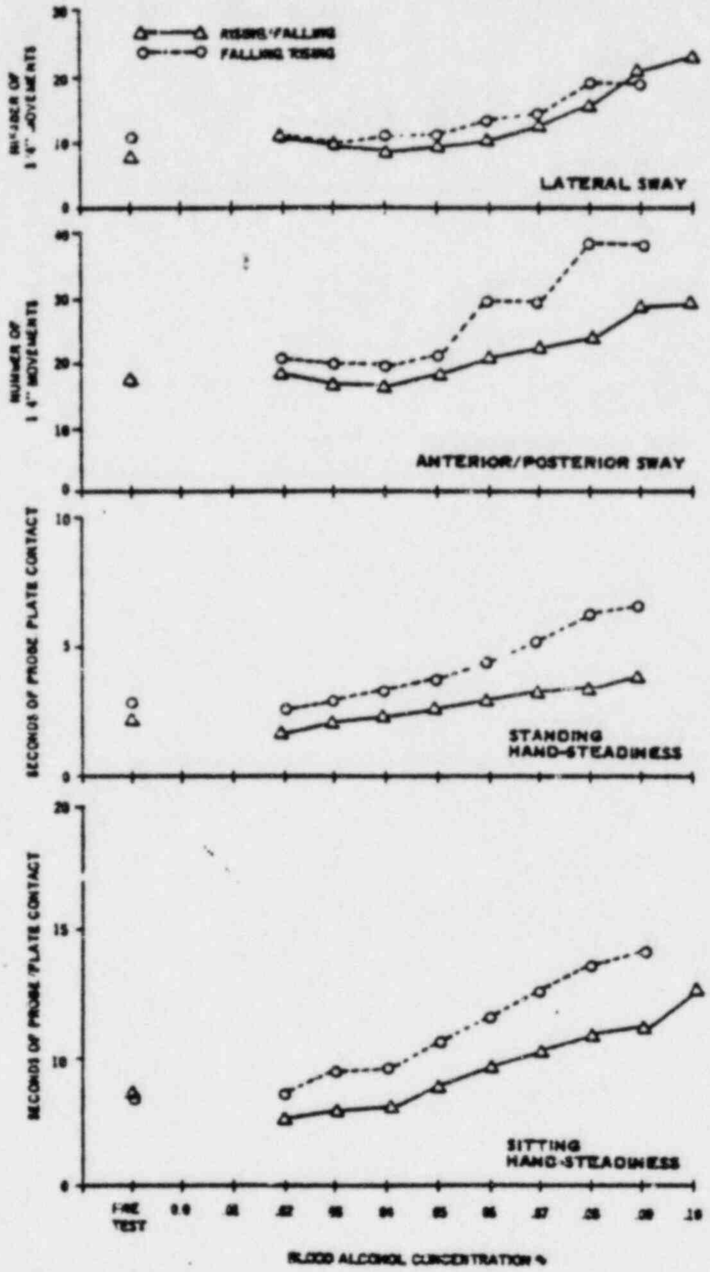


Figure 11. Performance as a function of Rising/Falling test sequence versus Falling/Rising test sequence

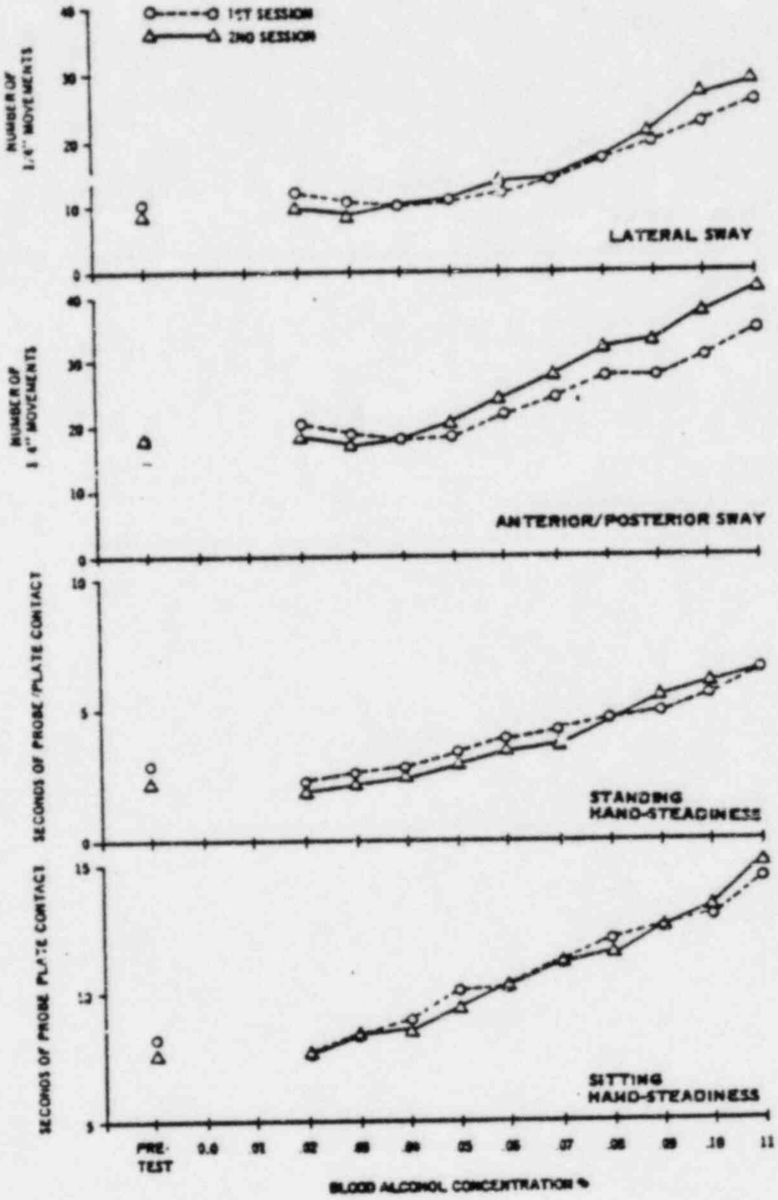


Figure 12. Performance as a function of First Experimental Test Session versus Second Experimental Test Session

and falling blood alcohol curves. However, the extent of this differential impairment is quite small in this study in comparison with other sources of differential impairment such as prior drinking history and order of experience with the behavioral test. The most likely reason for the relatively small Mellanby effect is the administration of the alcohol treatments at rates more typical of non-laboratory human consumption than usually found in experimental studies. In any case, regardless of the reason for this small Mellanby effect, it scarcely can be considered a sufficient source of variability in the relationship between driving impairment and BAC level as to be a legal defense against impairment based on a determination of BAC level.

A most interesting finding of this study was that the Mellanby effect in chronic heavy alcohol imbibers was as great or greater than in moderate drinkers despite clear-cut evidence of greater chronic tolerance in the heavy drinkers.

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APPENDIX A

EXPERIMENTAL FACILITY, APPARATUS AND TEST PROCEDURES

APPENDIX A

EXPERIMENTAL FACILITY, APPARATUS AND TEST PROCEDURES

Forty male subjects (20 social drinkers and 20 heavy drinkers) were tested on two occasions, once as they were becoming intoxicated and on another occasion as they were becoming sober. Test order was counter-balance so that half of the subjects were tested first during a period when their blood alcohol concentration (BAC) was rising, and half were tested first during a period when their BAC was falling.

Measures of performance were obtained at various BACs under the rising and falling blood alcohol conditions on tests of standing hand-steadiness, sitting hand-steadiness, body sway, and auditory divided attention. A gas chromatograph was used to determine BAC.

EXPERIMENTAL FACILITY

The experiment was conducted in the facility diagrammed in Figure A-1. It consisted of a lounge and two testing rooms. Each testing room was air conditioned and contained apparatus for the divided attention, sway, and hand-steadiness tests. The lounge contained the intoximeter, a refrigerator, a micro-oven, two couches, a color TV, and reading material available for subjects' use when they were not being tested.

APPARATUS AND TEST PROCEDURES

The four experimental tasks used to measure possible impairment effects of alcohol are presented in the order in which they were administered to the subjects.

Standing Hand-Steadiness

During this test, the subject stood holding a stylus inserted into a hole in a 4" x 6" brass plate. The tip of the stylus was a cylindrical steel rod 1 mm in diameter and 5.17 cm long. The hole in which the stylus was inserted was 6.4 mm in diameter. Any contact between the stylus and the plate activated an electric stop clock (Lafayette Instrument, Model 54014) which recorded the duration of contact, an electronic counter (Beekman Universal, Model 736 OHR) which counted the number of contacts, and an audio oscillator (Hewlett-Packard, Model 202D) which generated a tone to indicate to the subject that contact was being made.

Plate height adjustment was made for each subject prior to the first test round. The plate was secured in a metal vise and the vise was placed on a height-adjust-

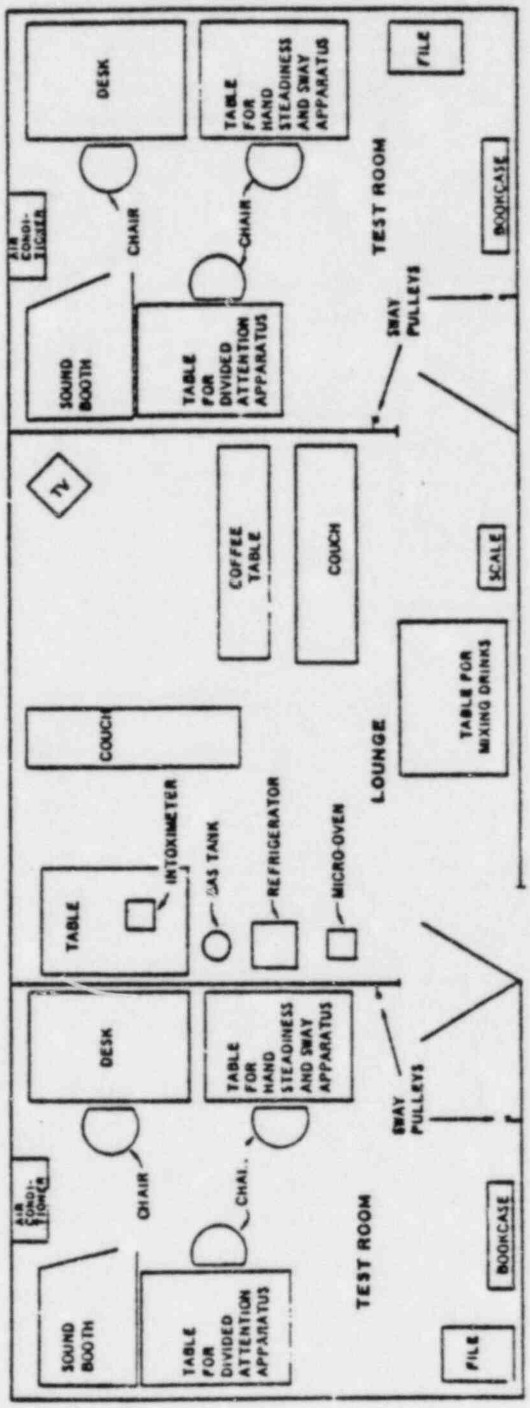

Figure A-1. Layout of the experimental facility able stand. Then, while facing the plate, the subject was asked to extend his arm at a right angle to his trunk. The height of the plate was adjusted by raising or lowering the stand to a level that brought the hole in the plate even with the subject's extended arm; the plate was maintained at this level for the remainder of the test sessions.

Before each test round, a check was made to ensure that the timer, counter, and stop watch were set to zero. Then the subject, while holding the stylus, took his stance. This involved standing on a marked line, one foot in front of the other, while facing the stand. Adjustment for distance was made by having the subject move along the marked line. The final position was attained when the probe, with the subject's arm fully extended, was inserted into the hole approximately half its length.

Once the required position was assumed, the subject was given several seconds to steady himself. Next, a single switch operating the counter, timer, and audio-oscillator was turned on and the stop watch was started. After 40 seconds, the switch was turned off, and test scores for duration of contact and number of contacts were entered in the test log. Finally, the timer, counter, and stop watch were reset to zero.

Sitting Hand-Steadiness

This task was essentially the same as standing hand-steadiness except that (1) the subject was seated and (2) the diameter of the hole in the metal plate was smaller than that used in the preceding task, and (3) the vise holding the metal plate was situated on a table in front of the subject.

Before each test round, a check was made to ensure that the counter, timer, and stop watch were set to zero. Next, a plate containing a hole with a diameter of 3.9 mm was secured in the vise and placed close to the edge of the table.

Following the preliminaries, the subject was seated in a chair facing the plate. The subject's distance to the plate was adjusted by moving the chair closer to or farther from the table, as required. The proper distance was attained when the probe was inserted to approximately one-half its length through the plate's hole while the subject's arm was fully extended.

Once the desired position was assumed, the subject was given several seconds to steady himself Then the switch operating the counter, timer, and the oscillator was turned on and simultaneously the stop watch was started. After a 40-second time period, the test scores were recorded and the timer, counter, and stop watch were reset to zero.

Body Sway

Body sway was measured by a device designed specifically for this experiment. The device consisted of a circular plastic disc approximately 7" in diameter with a series of small bar magnets mounted around its circumference. A dual pulley assembly was attached to the center of the disc and a string attached to each pulley. A small lead weight was attached to the end of one string wound on its pulley so as to exert a force tending to rotate the disc in a clockwise direction. The string connected to the other pulley was wound in the opposite direction and was secured at its other end to a leather harness attached around the upper torso of the subject. As the subject swayed back and forth, the disc would rotate back and forth, either because of the direct force applied by the subject as he swayed away from the device or by the force exerted by its counterbalancing weight as he swayed toward the device. The diameter of the disc, the location of the magnets, and the ratio of the pulley to the disc caused a magnet to pass a magnetic reed relay causing its contacts to close and increment a magnetic digital counter approximately each quarter of an inch of subject sway. Two such devices mounted at 90° to each other were attached to the subject so as to measure separately lateral and anterior/posterior sway.

Before each test round, a check was made to ensure that the lateral and anterior/posterior counters and the stop watch were set to zero and that the power operating the counters was turned off. The subject took his position on a square outlined on the floor. The harness was attached, in all cases, high on the chest with the strap passing immediately below the armpits. After the strings coming from the pulleys were properly secured, the subject was asked to put his head back and to close his eyes.

Once the proper position was assumed, the power and stop watch were turned on simultaneously; after 60 seconds, the power was turned off. The pulley strings were then disengaged from the harness and the harness removed from the subject. Finally, test scores were entered in the log and the counters and stop watch were reset to zero.

Auditory Divided Attention

The auditory divided attention task required the subject to attend to different auditory stimuli presented simultaneously, one to each ear. In his left ear he heard a three-second burst of Gaussion noise in which was embedded, on some trials, a one-second burst of 1,000 Hertz tone. When present, the one-second tone signals were randomly distributed within the three-second noise burst.

The signal-to-noise ratio* was selected such that the tone was just above the masking level of the noise, e.g., just about threshold. At the same time, the noise (and signal, when present) was heard in the left ear, the subject heard in his right ear a series of six digits, spaced at 1/2-second intervals. Following a seven-second period of silence, during which the subject was required to state whether or not the tone had been present in the noise and repeat the digits in their correct order, the stimuli were presented again. A single test session consisting of 100 trials (paired stimulus presentations) lasted approximately 17 minutes.

All test stimuli were pre-recorded on magnetic tapes. During the experiment a TANDBERG model 3000X tape deck and SONY model TA-1010 amplifier were used to feed a pair of Fisher model HP-100 stereo headsets. During all tests the subject was seated in an Industrial Acoustics Co., Model 250 "Mini" sound-proofed enclosure. Communication between the subject and the experimenter was accomplished via an intercom system.

Prior to the start of each test day, the tapes for the test session were gathered and stacked in the order of their eventual use. Corresponding preprinted score sheets, which were sequenced in the order of the stacked tapes, were placed in the log book.

Immediately preceding each test round, the appropriate tape was selected and mounted on the tape deck. A calibration check was then taken with a Hewlett-Packard, 400 HR, Vacuum Tube Voltmeter and the necessary corrections made, to ensure that the noise-to-voice ratio was at the assigned level. The subject, before entering the soundproof booth for the day's first test round, was given a short briefing in order to refresh his memory on the method of responding to the tape's inputs. After the subject was seated in the booth, checks were made to ensure that he was wearing the headset correctly (i.e., the "right" earphone on the right ear, the "left" earphone on the left ear) and that the booth's microphone was turned on. A final check confirmed that the booth's door was completely closed.

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*Originally, the level of tone on the divided attention task was 15 decibels below the level of the noise for all subjects. Midway during the data collection period, however, two additional sets of tapes were utilized, one with the tones 16 decibels below the level of the noise, and one with tones 17 decibels below the level of the noise. This was done in hopes of making the test more sensitive to the effects of alcohol. Individual subjects, however, were always tested at the same decibel level for all test trials.

The subject's responses were transmitted to the experimenter via a loudspeaker situated on a table adjacent to the booth. All responses were checked off immediately on the corresponding score sheet. A correct response was indicated by a check mark next to the "answer," while an incorrect one caused the "answer" to be circled. Upon completion of the test round, the subject left the booth, the test tape was rewound and removed from the tape deck. The score sheet was tallied, and scores were recorded in the log.

APPENDIX B

SUBJECT SCREENING QUESTIONNAIRES

QUESTIONNAIRE BASED ON CAHALAN STUDY (1969)

NAME ____________ DATE OF BIRTH ____________

ADDRESS ____________ TELEPHONE ____________

____________ OTHER PHONE ____________

MARITAL STATUS ____________ HEIGHT ________ WEIGHT ________

EDUCATION ____________ OCCUPATION ____________

INCOME: BELOW $5K___ $5-7.5K___ $7.5-10K___ $10-15K___ ABOVE $15K___

CURRENT DRIVER'S LICENSE: YES_____ NO_____

AVAILABILITY FOR TESTING:

_____MON _____TUES _____WED _____THUR _____FRI

1 2 3 4 5

DO YOU EVER DRINK ALCOHOLIC BEVERAGES? YES_____ NO_____

1. Give the subject page 1 of the questionnaire and say, "On this page please put a check mark next to the answer that tells how often you usually have wine." Repeat for beer and whiskey or liquor.

FREQUENCY

Wine	1	2	3	4	5	6	7	8	9	10	11
Beer	1	2	3	4	5	6	7	8	9	10	11.
Whiskey	1	2	3	4	5	6	7	8	9	10	11

2. For each category of drink (i.e., wine, beer, whiskey or liquor) for which the subject has checked a drinking frequency of "about once a month" (#8) or a higher frequency, you will ask the following further questions which are designed to determine the quantity of his consumption of that beverage. In this portion of the questionnaire you will hand the subject a card with the categories describing quantity with which he is to respond to the subsequent questions, which will be asked verbally.

WINE

1. Three or more times a day
2. Two times a day
3. Once a day
4. Nearly every day
5. Three or four times a week
6. Once or twice a week
7. Two or three times a month
8. About once a month
9. Less than once a month but at least once a year
10. Less than once a year
11. Never had drinks with wine

BEER

1. Three or more times a day
2. Two times a day
3. Once a day
4. Nearly every day
5. Three or four times a week
6. Once or twice a week
7. Two or three times a month
8. About once a month
9. Less than once a month but at least once a year
10. Less than once a year
11. Never had drinks with beer

WHISKEY OR LIQUOR

1. Three or more times a day
2. Two times a day
3. Once a day
4. Nearly every day
5. Three or four times a week
6. Once or twice a week
7. Two or three times a month
8. About once a month
9. Less than once a month but at least once a year
10. Less than once a year
11. Never had drinks with whiskey or liquor

You say, "I will be asking some questions about how often you have drunk some beverages. Please pick whichever answer on this card seems to best describe how often you drink that amount of beverage." Then ask the following questions. (Notice that if he gives a high frequency response to a large quantity of beverage, the instruction requires you to skip to the next beverage as there is no point in asking about small quantities after he tells you he always drinks large quantities.)

WINE

3. If has wine about once a month or more often, ask the following. Repeat for beer and whiskey or liquor.

3a. Think of all the times you have had <u>wine</u> recently. When you drink wine, how often do you have as many as five or six glasses?

1.* Nearly every time
2.* More than half the time
3. Less than half the time
4. Once in a while
5. Never

3b. When you drink <u>wine</u>, how often do you have three or four glasses?

1.* Nearly every time
2.* More than half the time
3. Less than half the time
4. Once in a while
5. Never

3c. When you drink <u>wine</u>, how often do you have one or two glasses?

1. Nearly every time
2. More than half the time
3. Less than half the time
4. Once in a while
5. Never

* If response is here, skip to next beverage.

QUANTITY

Wine	5a) 1 2 3 4 5	Beer 4a) 1 2 3 4 5	Whiskey 5a) 1 2 3 4 5
	b) 1 2 3 4 5	b) 1 2 3 4 5	b) 1 2 3 4 5
	c) 1 2 3 4 5	c) 1 2 3 4 5	c) 1 2 3 4 5

QUANTITY - VARIABILITY CLASS from Chart 1

Wine______________ Beer______________ Whiskey______________

QUANTITY-FREQUENCY-VARIABILITY CLASS from Chart 2

Heavy Light Moderate Infrequent Abstainer

HEALTH

1. How is your health? Poor____ Fair____ Good____ Excellent____.
2. Are you currently taking any drugs or medication? ____________________
3. Have you consulted with or been under a doctor's care within the past year?
   Reason____
4. Do you have or have you ever had:
   - Ulcers______________________
   - A heart condition______________________
   - Kidney disease______________________
   - Liver disease______________________
   - Muscular disorder______________________
   - Nervous disorder______________________

   Brief description____
5. Do you have any problems with your eyesight?
   - Yes (specify)______________________________________
   - No__________
6. Do you have any problems with your hearing?
   - Yes (specify)______________________________________
   - No__________

Quantity-Variability Class	Model Quantity (Amount drunk "nearly" every time" or "more than half the time")	Maximum Quantity (Highest quantity drunk)
1	5-6	5-6
2	3-4	5-6 "less time 1/2 time"
3	3-4	5-6 "once in a while
4	No mode specified	5-6 "less than 1/2 time"
5	3-4	3-4
6	1-2	5-6 "less than 1/2 time"
7	No mode specified	5-6 "once in a while"
8	1-2	5-6 "once in a while"
9	1-2	3-4 "less than 1/2 time"
10	1-2	3-4 "once in a while
11	1-2	1-2

Q-F-V Group	Frequency (of any alcoholic beverage)	Quantity-Variability Class (beverage drunk most often)
1. Heavy Drinkers 12% of weighted total		
	a. Three or more times a day	1-11
	b. Twice a day	1-9
	c. Every day or nearly every day	1-8
	d. Three or four times a week	1-5
	e. Once or twice a week	1-4
	f. Two or three times a month	1
2. Moderate Drinkers 13%		
	a. Twice a day	10-11
	b. Every day or nearly every day	9-10
	c. Three or four times a week	6-9
	d. Once or twice a week	5-9
	e. Two or three times a month	2-8
	f. About once a month	1-6
3. Light Drinkers 28%		
	a. Every day or nearly every day	11
	b. Once to four times a week	10-11
	c. Two or three times a month	9-11
	d. About once a month	7-11
4. Infrequent Drinkers 15%		
	Drank less than once a month but at least once a year. (Quantity questions not asked.)	
5. Abstainers 32%		
	Drank none of the 3 beverages as often as once a year. (Quantity questions not asked.)	

QUESTIONNAIRE BASED ON OATES-McCOY STUDY (1973)

NAME ______________________________ DATE ________________

Drinking Pattern

1. How much distilled spirits (i.e., whiskey, gin, vodka) do you generally drink on any one occasion?

N.A. (doesn't drink whiskey)	______	0
One shot (1--1-1/2 ounces)	______	1
Two-three shots	______	2
Four-five shots	______	4
Six-seven shots	______	6
Eight-ten shots	______	8
One pint	______	10
One pint to one fifth	______	15
More than one fifth	______	20

2. How much beer do you generally drink on any one occasion?

N.A. (doesn't drink beer)	______	0
One bottle (12 ounces)	______	1
Two-three bottles	______	2
Four-five bottles	______	4
One to two six-packs	______	8
More than two six-packs	______	15

3. How much wine do you generally drink on any one occasion?

N.A. (doesn't drink wine)	______	0
One glass (3-4 ounces)	______	1
Two-three glasses	______	2
Four-five glasses	______	4
One bottle	______	10
More than one bottle	______	15

4. How often do you drink during:
(Mark appropriate space in each column.)

	Mornings	Lunch	Afternoon	Dinner	Evenings
Never	0	0	0	0	0
Monthly or less	5	1	1	1	1
Several times each month	10	2	3	2	2
Weekly	15	3	7	3	3
Several times each week	25	5	10	4	4
Daily	30	8	15	5	5

5. Where do you drink most often?

Private home ____ 1

Bar/restaurant ____ 2

Other (specify) ______________________ ____ TBD

6. When you drink, are you generally

With spouse/family members ____ 1

With friends ____ 2

With barroom clientel ____ 4

Alone ____ 8

7. How often during the past 12 months have you become physically ill as a result of drinking:

Never ____ 0

Once ____ 2

Twice ____ 5

Several or more times ____ 8

Describe drinking situation at this time(s): ______________________

____

____

Related Indices

8. Have you ever been told that you have alcohol-related kidney disorders, liver trouble, or cirrhosis? Yes______(1) No______(0)

9. Have you ever had Delirium Tremens, severe shaking, hallucinations? Yes______(5) No______(0)

0. Have you ever awakened the morning after drinking and found you could not recall a part of the evening? Yes______(1) No______(0)

1a. Have you ever attended a meeting of Alcoholics Anonymous (AA)? Yes______(1) No______(0)

b. If no, has anyone ever recommended that you attend such meetings? Yes______(1) No______(0)

2. Have you ever seen a clergyman, social worker, doctor, etc. for help with a problem related to your drinking? Yes______(1) No______(0)

3. Have you ever been in a hospital because of your drinking? Yes______(1) No______(0)

4. Have you ever been convicted for "drunk and disorderly" or "public intoxication?" Yes______ No______ If yes, how many times?______(x2)

5. Have you ever been convicted for "drunk driving," "driving while intoxicated," or "driving while under the influence of alcoholic beverages?" Yes______ No______ If yes, how many times?______(x2)

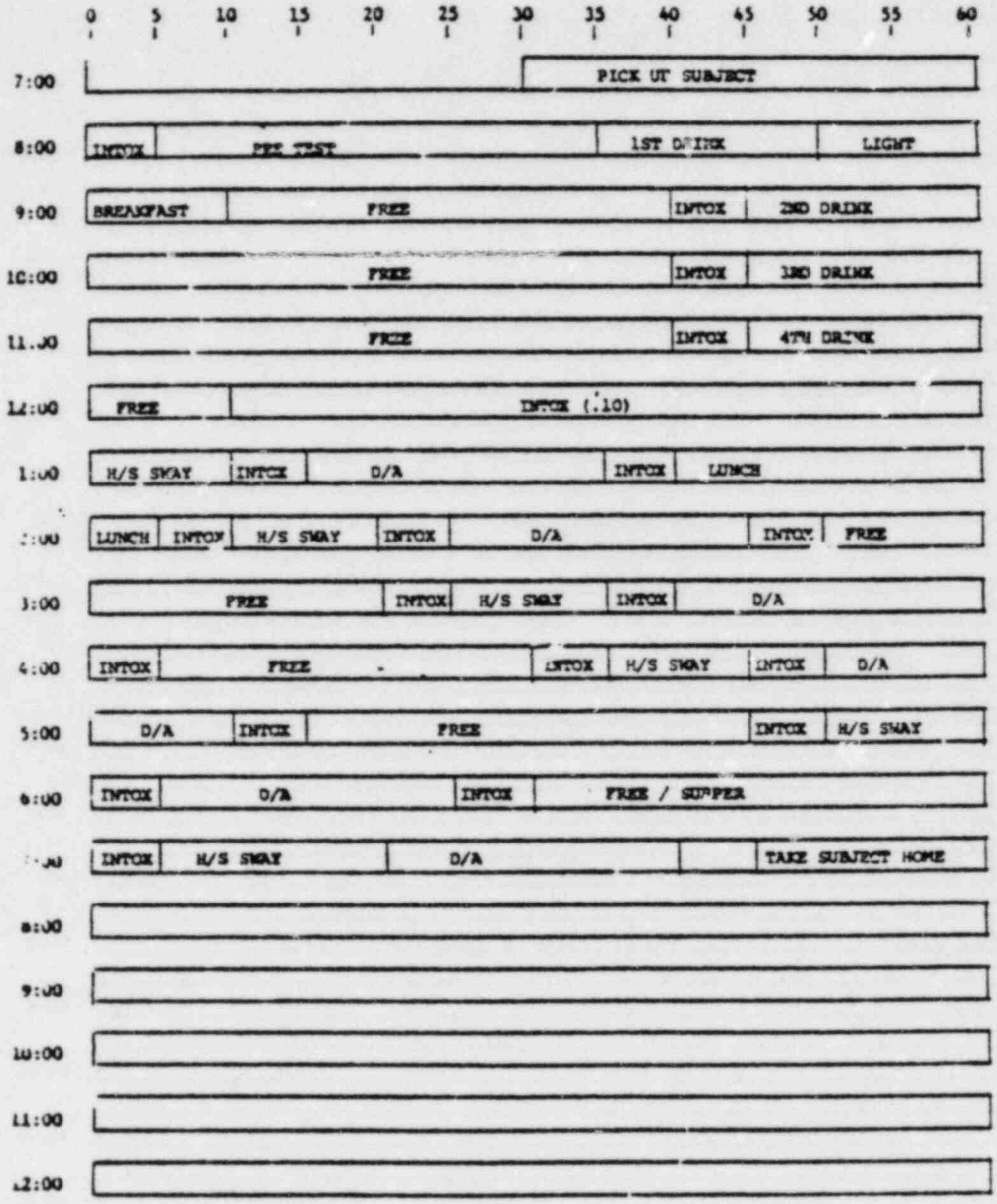
APPENDIX C

EXPERIMENTAL SCHEDULES
DRINKING SCHEDULES
SUBJECT RECRUITING NOTICE
SUBJECT CHARACTERISTICS

EXPERIMENTAL SCHEDULE RISING-MODERATE GROUP

	0	5	10	15	20	25	30	35	40	45	50	55
7:00							PICK UP SUBJECT					
8:00	INTOX	PRE TEST					LARGE BREAKFAST					
9:00	FREE											
10:00	FREE											
11:00	LIGHT LUNCH						FREE			1ST DRINK		
12:00	FREE	H/S SWAY		INTOX	D/A				INTOX	2ND DRINK		
1:00	FREE	H/S SWAY		INTOX	D/A				INTOX	3RD DRINK		
2:00	FREE	H/S SWAY		INTOX	D/A				INTOX	4TH DRINK		
3:00	FREE	H/S SWAY		INTOX	D/A				INTOX	5TH DRINK		
4:00	FREE	H/S SWAY		INTOX	D/A				INTOX	SUPPER		
5:00				INTOX								INTOX
6:00				INTOX								INTOX
7:00				INTOX								INTOX
8:00				INTOX								INTOX
9:00				INTOX								INTOX
10:00	TAKE SUBJECT HOME AT BAC < .04											
11:00												
12:00												

EXPERIMENTAL SCHEDULE RISING-MODERATE GROUP



EXPERIMENTAL SCHEDULE RISING-HEAVY GROUP

	0	5	10	15	20	25	30	35	40	45	50	55	60
7:00							PICK UP SUBJECT						
8:00	INTOX	PRE TEST						LARGE BREAKFAST					
9:00	FREE												
10:00	FREE												
11:00	LIGHT LUNCH						FREE			1ST DRINK			
12:00	FREE	H/S SWAY		INTOX	D/A				INTOX	2ND DRINK			
1:00	FREE	H/S SWAY		INTOX	D/A				INTOX	3RD DRINK			
2:00	FREE	H/S SWAY		INTOX	D/A				INTOX	4TH DRINK			
3:00	FREE	H/S SWAY		INTOX	D/A				INTOX	5TH DRINK			
4:00	FREE	H/S SWAY		INTOX	D/A				INTOX	6TH DRINK			
5:00	FREE	H/S SWAY		INTOX	D/A				INTOX	7TH DRINK			
6:00	FREE	H/S SWAY		INTOX	D/A				INTOX	SUPPER			
7:00				INTOX						INTOX			
8:00				INTOX						INTOX			
9:00				INTOX						INTOX			
10:00				INTOX						INTOX			
11:00				INTOX						INTOX			
12:00				INTOX	TAKE SUBJECT HOME AT BAC < .04								

EXPERIMENTAL SCHEDULE RISING-HEAVY GROUP

	0	5	10	15	20	25	30	35	40	45	50	55	60
7:00							PICK UP SUBJECT						
8:00	INTOX	PRE TEST						1ST DRINK			LIGHT		
9:00	BREAKFAST		FREE						INTOX	2ND DRINK			
10:00	FREE								INTOX	3RD DRINK			
11:00	FREE								INTOX	4TH DRINK			
12:00	FREE		INTOX (.15)										
1:00	H/S SWAY		INTOX	D/A				INTOX	LUNCH				
2:00	FREE					INTOX	H/S SWAY		INTOX	D/A			
3:00	D/A	INTOX	FREE									INTOX	
4:00	H/S SWAY		INTOX	D/A				INTOX	FREE				
5:00	FREE	INTOX		H/S SWAY	INTOX	D/A				INTOX	FREE		
6:00	FREE				INTOX	H/S SWAY		INTOX	D/A				
7:00	INTOX	FREE/SUPPER					INTOX	H/S SWAY		INTOX	D/A		
8:00	D/A		INTOX	FREE						INTOX	H/S SWAY		
9:00	INTOX	D/A				INTOX	FREE						
10:00	INTOX	H/S SWAY		D/A					TAKE SUBJECT HOME				
11:00													
12:00													

Drink Schedule - Heavy Rising - 1 oz./70 lbs.

1 oz./70 Lbs.

Weight	Amt.
113-131	1-3/4
132-149	2
150-167	2-1/4
168-185	2-1/2
186-200	2-3/4

Adjustments - First 5 Drinks

Drink No.	Expected BAC Level After Drink	If Equal to or Less Than	If Equal to or Less Than
1	.02	.01, Add 1/2 oz.	.03, Sub. 1/2 oz.
2	.04	.03, Add 1/2 oz.	.05, Sub. 1/2 oz.
3	.06	.05, Add 1/2 oz.	.07, Sub. 1/2 oz.
4	.08	.07, Add 1/2 oz.	.09, Sub. 1/2 oz.
5	.10	.09, Add 1/2 oz.	.11, Sub. 1/2 oz.

1 oz./55 Lbs.

Weight	Amt.
118-130	2-1/4
131-144	2-1/2
145-158	2-3/4
159-172	3
173-186	3-1/4
187-200	3-1/2

Adjustments - 6th & 7th Drinks - 1 oz./55 Lbs.

6	.125	.115, Add 1/2 oz.	.135, Sub. 1/2 oz.
7	.15		

Drink Schedule - Heavy - Falling - 1 oz./50 Lbs.

Weight	Amt.
119-131	2-1/2
132-144	2-3/4
145-156	3
157-169	3-1/4
170-182	3-1/2
183-195	3-1/4
196-200	4

Adjustments

Drink No.	Expected BAC Level After Drink	If Equal to or Less Than	If Equal to or Less Than
1	.038	N/A	N/A
2	.075	.065, Add 1 Oz.	.085, Sub. 1 oz.
3	.113	.11, Add 1 oz.	.13, Sub. 1 oz.
4	.15	N/A	N/A

Drink Schedule - Moderate Rising - 1 oz./70 Lbs.

Weight	Amt.
113-131	1-3/4
132-149	2
150-167	2-1/4
168-185	2-1/2
186-200	2-3/4

Drink No.	Expected BAC Level After Drink	Adjustments	
		If Equal to or less Than	If Equal to or less Than
1	.02	.01, Add 1/2 oz.	.03, Sub. 1/2 oz.
2	.04	.03, Add 1/2 oz.	.05, Sub. 1/2 oz.
3	.06	.05, Add 1/2 oz.	.07, Sub. 1/2 oz.
4	.08	.07, Add 1/2 oz.	.09, Sub. 1/2 oz.
5	.10	N/A	N/A

Drink Schedule - Moderate Falling - 1 oz./60 Lbs.

Weight	Amt.
112-127	2
128-142	2-1/4
143-157	2-1/2
158-172	2-3/4
173-187	3
188-200	3-1/4

Drink No.	Expected BAC Level After Drink	Adjustments	
		If Equal to or Less Than	If Equal to or Less Than
1	.025	N/A	N/A
2	.05	.04, Add 1 oz.	.06, Sub. 1/2 oz.
3	.075	.065, Add 1 oz.	.085, Sub. 1/2 oz.
4	.10	N/A	N/A

SUBJECT RECRUITING NOTICE

RESEARCH SUBJECTS WANTED

(Males weighing under 200 lbs.)

Would you be interested in serving as a paid volunteer subject in an alcohol research study being sponsored by the U.S. Department of Transportation?

This would involve your coming to a research laboratory at the System Development Corporation in Santa Monica. You would come the same day each week for three consecutive weeks.

The first session would be about four hours in length. The second and third sessions during which you would be required to consume a quantity of alcohol (vodka and mix) could last anywhere from 12 to 20 hours. Your meals and transportation to and from the laboratory on the second and third day of the study will be furnished.

During the study sessions, you will be required to perform various special tests. When you are not being tested, you may read, study, or watch TV.

Subjects will be paid at the rate of $1.65 per hour for the first eight hours of each test session and then at a rate of $2.48 per hour for all additional time. In order to participate in the study, subjects must be available for all three experimental sessions at the times agreed upon and must not have consumed alcohol or drugs in the preceding 24 hours. In addition to their hourly pay, subjects who perform well and meet all requirements of the study will receive a $50.00 bonus.

If you think you might be interested in participating in the study, please call EX 3-9411, extension 574.

Subject Characteristics

Variable	Numbers in Group	
Age	**Heavy**	**Social**
21 - 25	9	5
26 - 30	3	10
31 - 35	2	
36 - 40	3	3
41 - 45	1	1
46 - 50	1	
51 - 55	1	
56 - 60		
61 - 65		1
Education	**Heavy**	**Social**
High School Graduate	9	5
Some College	8	4
College Graduate	1	4
Post Graduate	2	7
Income	**Heavy**	**Social**
Less than $5,000	10	12
$5,000 to $7,499	7	1
$7,500 to $9,999		1
$10,000 to $14,999	3	2
Over $15,000		4
Weight	**Heavy**	**Social**
125 - 149	4	5
150 - 174	6	6
175 - 199	8	8
200 - 225	2	1
Marital Status	**Heavy**	**Social**
Single	12	10
Married	4	8
Separated/Divorced	4	1
Widowers		1