THE RELATIONSHIP BETWEEN POSITIONAL ALCOHOL NYSTAGMUS AND ACCURACY OF ESTIMATION OF BLOOD ALCOHOL

by

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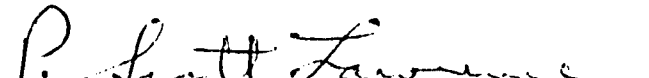

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Although the literature on the use of discrimination of blood alcohol levels in the treatment of alcoholism has implied strongly that awareness of levels of blood alcohol is an important therapeutic consideration, little information is available regarding the mechanism of action for the relationship between accurate discrimination and therapeutic efficacy. This study sought to extend the state of knowledge about blood alcohol discrimination through the investigation of a concomitant of levels of alcohol in the blood, i.e., positional alcohol nystagmus.

Five subjects, hospitalized for heavy drinking, were trained initially in the discrimination of blood alcohol, using all available cues, including positional alcohol nystagmus (PAN), a lateral eye movement consisting of alternating rapid and slow phases. The hypothesis under consideration was that levels of alcohol in the blood served more powerful discriminative stimulus functions when the subjects had been allowed to assume the body and head positions necessary for PAN production than when they had been allowed only to assume control body and head positions. Subjects estimated blood alcohol following drink consumption and immediately subsequent to having assumed either PAN or Non-PAN body and head positions, the

experimental manipulations. Five sessions under each of the two experimental conditions were carried out for each subject. Positional alcohol nystagmus was assessed during PAN and Non-PAN body and head positions through the electronystagmographic measurement of lateral eye movements. A largely unsuccessful attempt was made at controlling for the effects of discrimination of strength of alcoholic beverage on the accuracy of estimation of blood alcohol. The discriminative stimulus effect of previous feedback for levels of blood alcohol was eliminated by allowing only one opportunity for estimation and subsequent Breathalyzer feedback per session.

Results were analyzed by an analysis of covariance, with accuracy of estimation of blood alcohol serving as the dependent variable and absolute levels of alcohol in the blood as the covariate. A significant F ratio indicated that subjects estimated more accurately following placement in the PAN body and head positions than following placement in the control position. Correlational analyses were performed through multiple regression techniques in order to evaluate the relative strengths of (1) estimation of drink strength, (2) actual nystagmus, and (3) verbal description of nystagmus in predicting subjects' estimates of levels of alcohol in the blood. Actual nystagmus and estimation of drink strength were found to best predict estimates of blood alcohol.

A negative relationship was found between accuracy of estimation of blood alcohol and severity of past drinking history.

Results were discussed with respect to the understanding of alcohol intoxication and the use of discrimination of blood alcohol in the treatment of heavy drinking habits.

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CHAPTER I

INTRODUCTION

Behavioral approaches to the modification of heavy drinking of alcohol in humans have been of two generic varieties. The first, reinforcement for non-drinking activities, has been represented in the "community-reinforcement" model of Hunt and Azrin (1973), in which an operant reinforcement approach was used to rearrange community reinforcers in order to shape and maintain actions incompatible with drinking. Heavy drinking was not dealt with directly, but was suppressed indirectly through procedures aimed at encouraging alternative activities.

The second approach emphasizes the direct diminution of heavy drinking through the use of aversive conditioning. Lemere, Voegtlin, Broz, and O'Hollaren (1942) have described a procedure in which the taste of alcoholic beverages is associated with nausea and vomiting induced by an injection of emetine or apomorphine. Excellent results over a 13-year follow-up period have been reported by Lemere and Voegtlin (1950).

In both the 'reinforcement' and 'punishment' approaches to the reduction of heavy drinking, total and lifelong abstinence from alcohol ingestion has been, until recently, the behavioral objective. Over the past five

years, however, several studies recommending the goal of moderate drinking have appeared in the literature (Lovibond and Caddy, 1970; Mills, Sobell, and Schaefer, 1971; Bigelow, Cohen, Liebson, and Faillace, 1972; Sobell, M. B. and Sobell, L. C., 1973a; Sobell, M. B. and Sobell, L. C., 1973b; Cohen, Liebson, and Faillace, 1973; Silverstein, Nathan, and Taylor, 1974; and Vogler, Compton, and Weissbach, 1975).

Discrimination of Blood Alcohol

Several studies have pointed to the importance of discrimination of alcohol levels in the blood in achieving the goal of moderate drinking. Lovibond and Caddy (1970) have reported on the ability of human subjects, referred for excessive drinking, to discriminate among levels of blood alcohol following consumption of alcoholic beverages. Estimation of alcohol in the blood after one training session was reported to reach levels of accuracy within ± 10 mg/100 ml, with a blood alcohol range of 0-80 mg/100 ml. Levels of alcohol in the blood which exceeded 65 mg/100 ml were then used as discriminative stimuli for aversive electro-shock following continued drinking, while levels falling below 65 mg per 100 ml were established as "safe signals" for drinking, i.e., no shock consequence. The physiological loci of cues for levels of alcohol in the blood were described as "idiosyncratic" and "proprioceptive."

Follow-up measures of drinking revealed success in achieving operationally defined "controlled drinking" in that drinking in the natural environment seldomly exceeded 70 mg of alcohol per 100 ml of blood. Lovibond and Caddy (1970) have implied that patients continued to estimate accurately levels of alcohol in the blood following training, although they have recommended further analysis of the treatment procedure.

Silverstein, Nathan, and Taylor (1974) have subjected the phenomenon of estimation of blood levels of alcohol to a more careful experimental analysis. In their study, accuracy of estimation was reported to vary positively with availability of Breathalyzer feedback for actual blood levels of alcohol. Thus, when Breathalyzer feedback was not available, accuracy was poor; when Breathalyzer feedback was available, accuracy of estimation was relatively high. Silverstein et al. (1974) felt that their results did not support the hypothesis that alcoholics are able to continue estimating accurately following removal of feedback. This inability occurred despite the use of variable schedules of reinforcement designed to prolong the accuracy of blood alcohol estimates. Silverstein et al. (1974) questioned subjects' long-term abilities to estimate accurately levels of alcohol in the blood following removal of Breathalyzer feedback in light of findings of highly variable success of patients in maintaining predetermined levels of controlled drinking.

A third study dealing with the discrimination of blood alcohol was that of Vogler et al. (1975). Little was reported in that study on the accuracy of estimation, except that subjects were required to attain accuracy of estimation within ± 10 mg/100 ml of the actual blood alcohol value. The range of blood alcohol was 0 - 50 mg/100 ml, a range that makes an estimate within a ± 10 mg/100 ml tolerance relatively probable. Nonetheless, Vogler et al. (1975) have concluded that the acquisition of accuracy in blood alcohol discrimination is important in the moderation of heavy drinking because it "creates an awareness of the degree of intoxication."

A comparison of the Silverstein et al. (1974) and Lovibond and Caddy (1970) findings on estimation accuracy suggests strongly that heavy drinkers are capable of discerning their level of intoxication during drinking episodes. Although Silverstein et al. (1974) found a slightly higher average discrepancy between estimated and actual blood alcohol levels than Lovibond and Caddy (1970), the former used a broader range of alcohol levels in the blood (0 - 150 mg/100 ml) than the latter (0 - 80 mg/100 ml). Therefore, the wider range of values for blood alcohol in the Silverstein et al. (1974) study allowed a wider margin for error. The amount of time required for training accurate estimates was minimal in both studies. Lovibond and Caddy (1970) reported accurate estimates following a

two-hour training session, and Silverstein et al. (1974) found accurate estimates during the first day of feedback for blood alcohol.

The determinants of accuracy of estimation in the Lovibond and Caddy (1970) and Silverstein et al. (1974) studies are unclear. The three most obvious possibilities are beverage strength, feedback from the Breathalyzer, and physiological effects of alcohol. The respective roles of these three variables are confounded inextricably in the Lovibond and Caddy (1970) paper. Although the experimenters reported instructions to subjects concerning subjective experiences associated with levels of alcohol in the blood, no attempts to manipulate or to measure physiological effects of alcohol were reported. Similarly, although actual Breathalyzer feedback undoubtedly contributed greatly to accuracy, it must certainly have done so in concert with concentration and temporal distribution of alcohol and psychophysiological feedback.

The Silverstein et al. (1974) study systematically varied the availability of Breathalyzer feedback. According to the authors, this manipulation pointed to Breathalyzer feedback as an "information anchor" in the accuracy of estimation of alcohol in the blood. Their data pointed to Breathalyzer feedback as a necessary condition, within the context of the study, for the accurate estimation of blood alcohol.

From a theoretical point of view, feedback from the Breathalyzer can influence accuracy in two ways. The first concerns the role of feedback in confirming the accuracy of an immediately preceding estimate, thus influencing the next estimate through a procedure akin to reinforcement. That is, the degree of accuracy determined by the feedback causes the subject to respond either similarly or dissimilarly to antecedent stimuli on the next trial. Feedback can also affect estimates by exerting a discriminative stimulus influence, however. If a subject is given an opportunity to estimate 30 minutes following a Breathalyzer reading of 50 mg alcohol per 100 ml blood, he is likely to estimate at or above that level, depending on whether or not he has consumed another drink. Subsequently, that subject would not be able to estimate accurately once feedback had been removed. Thus, because of the multiple opportunities to estimate and to receive Breathalyzer feedback within a session in the Silverstein et al. (1974) investigation, it is not clear, on the basis of the present analysis, that continued feedback is a necessary condition for prolonged accuracy in estimation of blood alcohol, as Silverstein et al. (1974) have implied.

The respective roles of drink concentration, Breathalyzer feedback, and psychophysiological feedback remain unclear, therefore, on the basis of existing literature describing the accuracy of estimation of blood alcohol. An

experimental analysis in which each of these variables could be systematically varied or controlled seems called for at this point.

Alcohol as a Discriminative Stimulus

The findings cited above suggest that alcohol is capable of exerting a discriminative stimulus function over the verbal behavior of human subjects. That is, following the effective sharpening of stimulus control, subjects' verbal responses to experimenter prompts come under the control of levels of alcohol in the blood. Theoretically, this stimulus control is influenced by the feedback about actual blood alcohol provided the subject by the experimenter subsequent to the verbal estimate.

Harris and Balster (1971) and Overton (1971) have pointed out the generality with which CNS-active drugs have served as discriminative stimuli in the control of learned behavior; furthermore, Overton (1971) has described an experiment in which alcohol was demonstrated to serve a discriminative stimulus function over the choice behavior of rats in a T-maze.

The locus of action of alcohol in the control of learned behavior is illuminated, perhaps, by findings in the literature which suggest that interoceptive stimulation can serve a stimulus function over operant behavior (Hull, 1933; Conger, 1951) and in classical conditioning (Bykov,

1957; Razran, 1961). Schuster and Brady (1971) have shown that varying infusion rates of dextrose-saline into the superior vena cava are capable of serving discriminative stimulus functions.

These findings, however, indicate only that interoceptive and exteroceptive stimulation can act in a similar manner. The question of locus of control arises in the case of interoceptive stimulus control because the sensory organs upon which interoceptive events are acting are not as obvious as the organs upon which such familiar stimuli as visual, auditory, and tactile events exert their actions. A very simple experiment could be designed to demonstrate that the eyes are critical in visual discrimination tasks. When subjects' eyes are open, specific visual events could serve discriminative functions; when eyes are closed, the same events could not serve as discriminative stimuli. Similarly, the question of locus of action when CNS-active drugs exert a discriminative stimulus function over learned behavior might be illuminated by experimentally manipulating body functions hypothesized to be active in the effects of these drugs on the organism.

The nature of the interoceptive stimuli which may be implicated in accurate discriminations of blood alcohol, as has been suggested by both Lovibond and Caddy (1970) and Silverstein et al. (1974), remains unexplicated. Suggestions have included feelings of warmth and relaxation, progressive

loss of anxiety in social situations, tightening of the skin on the cheeks, and apparent "popping" of ears (Lovibond and Caddy, 1970). Silverstein et al. (1974) have referred only to rather vague signs of emotional and physical change correlating with specific blood alcohol levels. Vogler et al. (1975) reported the use of a "body awareness script," after Piaget, through which subjects were instructed to attend to and assess the quality and degree of "physical sensations" which accompanied varying levels of blood alcohol. Through instructions to attend only to these sensations and through variation of the strength of mixed drinks (no variation was possible for beer or wine drinkers), Vogler et al. (1975) trained subjects to use only private sensations in making estimates of blood alcohol.

Thus, the existing studies on discrimination of blood alcohol have done little to illuminate the specific loci of alcohol effects.

Nystagmus as a Function of Alcohol Levels in the Blood

Naitoh (1972) has reported on the effect of alcohol on the autonomic nervous system of humans. His conclusions concerned attempts to validate extant theories of the etiology of alcoholism by observing autonomic behavior subsequent to the ingestion of alcoholic beverages. In most cases, the autonomically mediated responses, such as heart rate

and GSR, were found to vary both across and within subjects. For example, heart rate was found to undergo first acceleration then deceleration as the result of alcohol intake. Blood pressure was found to vary according to Wilder's (1962) "Law of Initial Value." Other psychophysiological, but not necessarily autonomically-mediated, responses of humans to alcohol included EMG spike activity from the temporal muscles and nystagmic eye movements. Spike activities in the temporal muscles have been found by Mizoi (Naitoh, 1972) to vary regularly with alcohol levels in the blood. These temporal muscle spikes have been found to disappear simultaneously with the appearance of "signs of drunkenness." Unfortunately, the procedure requires the insertion of needle electrodes into the temporal muscles, a feature not readily adaptable to routine clinical applications.

Nystagmic eye movements have been noted to relate to alcoholic intoxication (Naitoh, 1972). Varieties of nystagmus which have been identified as covarying with levels of alcohol in the blood include the following: (1) positional alcohol nystagmus (PAN I and II), a horizontal nystagmus which occurs with alcohol in the blood and when the head is placed laterally with the subject on his back; (2) alcohol gaze nystagmus (AGN), another horizontal nystagmus occurring with a lateral gaze (30-40 degrees deviation); (3) roving ocular movements (ROM), a sinusoidal movement of

the eyes when the subject is supine with eyes closed; (4) optokinetic nystagmus (ON), a reduction, due to alcohol, in nystagmic eye movements in a situation in which the subject is following a vertical black stripe moving on a white field. Each of these measures represents a relatively sensitive index of blood alcohol during absorption period -- that is, immediately following drinking. PAN I appears reliably within 30 minutes following drinking at a mean level of alcohol in the blood of approximately 38 mg/100 ml (Aschan, Bergstedt, Goldberg, and Laurell, 1956). ON has been noted to attenuate with levels of blood alcohol as low as 50 mg/100 ml (Naitoh, 1972).

PAN I varies roughly monotonically in amplitude and frequency with levels of alcohol in the blood, according to Aschan et al. (1956) and Goldberg (1970). The greater the level of alcohol in the blood, therefore, the greater the intensity and the higher the frequency of positional alcohol nystagmus. This correspondence between measures of nystagmus and blood alcohol renders PAN of particular interest in the search for a psychophysiological effect of alcohol that can be used to assist accurate estimation of alcohol levels in the blood. PAN I is of further interest in this respect because of its early appearance in the course of intoxication. Also, PAN I and II have an intuitive appeal in the clinical investigation of alcohol intoxication because of their bimodal characteristics, to be discussed below.

In the Aschan et al. (1956) study, positional alcohol nystagmus I and II were differentiated. First, PAN I, which appeared at 38 mg/100 ml alcohol in the blood, originated about 30 minutes following ingestion of the alcoholic beverage and lasted for approximately three hours. Goldberg (1970) has demonstrated that the latency and duration of PAN I are independent of alcohol dose and maximal blood levels. In Aschan et al. (1956), PAN II appeared approximately five hours subsequent to the ingestion of alcohol and had a duration of approximately six hours. PAN I and II are differentiated on the basis of the rapid eye movement phase of the nystagmus. PAN I is defined by a rapid phase laterally in the direction of the head placement, with a slow phase returning in the opposite direction. PAN II is identified by a rapid phase in the opposite direction from the placement of the head and slow phase returning in the direction of the head placement. PAN II seems to be a post-intoxication phenomenon, in that it usually appears during the elimination phase of the blood alcohol curve and always dissipates long after the disappearance of detectable alcohol in the blood. Thus, PAN II is correlated temporally with "hangover," both in terms of temporal proximity and subjective symptoms of "hangover" (Aschan et al., 1956; Goldberg, 1970); hence, its intuitive appeal to clinical applications. Wallgren and Barry (1970), in a review of the alcohol literature,

have commented on the high stability and uniformity of PAN I in both humans and lower animal species. Hence, because of its high correlation with alcohol intoxication and its reliability of onset, PAN I represents a potentially useful area for research.

If it can be demonstrated that, in addition to co-varying with blood alcohol, PAN I is discriminable at various intensities by the drinking subject, it is conceivable that the training of excessive drinkers in the discrimination of levels of alcohol in the blood through attention to nystagmic cues could be of considerable value in the treatment of dangerous drinking habits.

In the present study, the attempt to demonstrate a relationship between accuracy of estimation of blood alcohol and the body position required for PAN was designed roughly within the framework of the Lovibond and Caddy (1970) and Silverstein et al. (1974) investigations. Discrete stimulus trials afforded subjects the opportunity to discriminate between the presence and absence of PAN I through the manipulation of body positions. The 'PAN' sessions consisted of allowing the subject to assume the body and head positions necessary for the production of positional alcohol nystagmus. Conversely, the 'Non-PAN' ('N-PAN') trials prohibited such positioning of the subject's body and head. Each subject then estimated levels of alcohol in the blood on the basis of cues subjectively available to him. Initial

and 'booster' training in discrimination of levels of alcohol in the blood and in attending to PAN I feedback insured the collection of asymptotic data. Following presentation of PAN or N-PAN body and head positions, subjects were asked to estimate levels of alcohol in the blood on the basis of all the cues available to them. Experimental subjects were trained according to the somewhat ambiguous guidelines of Lovibond and Caddy (1970) and Silverstein et al. (1974), with the addition of systematic exposure to discrete opportunities for PAN I. Discrete trials were presented at the rate of one trial per experimental session. Each opportunity for estimation of blood alcohol was unconfounded, therefore, by previous Breathalyzer feedback within that drinking session. Alcoholic beverages were administered at concentrations calculated to generate several different levels of alcohol in the blood across experimental sessions.

This procedure was intended to address the question regarding the degree to which nystagmus is effective in the discrimination of stages of intoxication. It was expected that PAN I, when available, would be capable of providing subjects with information sufficient to make accurate determinations of their own blood levels of alcohol. Support for this hypothesis should generate further investigations into the circumstances under which positional alcohol nystagmus constitutes a sufficient condition for the discontinuation of a drinking episode by alcoholics.

CHAPTER II

METHOD

Subjects

Six male subjects involved in an alcoholism rehabilitation program in an inpatient setting volunteered to participate in the study. All subjects had voluntarily remained in the rehabilitation program following inpatient detoxification, regardless of the initial status of the commitment, voluntary or involuntary, and all had verbalized motivation to change dangerous drinking habits. Assessment involved evaluation of the medical records accumulated on each subject, including screening out of acute or chronic medical problems, psychosis, organic brain syndromes, other neurological disturbances, and mental retardation. Nystagmographic evaluation for spontaneous nystagmus occurring with the subject reclined and the head in a lateral position was completed at least 48 hours subsequent to any alcohol intake, as Nsamba and Al-Marashi (1972) have demonstrated significant alcohol influences on eye movement as long as 30 hours following drinking.

All subjects and the experimenter entered into a contract, in which each subject committed himself to remain and participate fully in the experimental procedures, unless confronted with an extremely uncomfortable situation

demanding withdrawal. The experimenter, reciprocally, agreed to consider, above all, the need for each subject to overcome dangerous drinking habits. The contract further guaranteed that each subject would be debriefed thoroughly following the completion of the research project. Subjects were told initially that the purpose of the investigation was to teach them to discriminate between varying levels of alcohol in the blood, a skill that was hypothesized to assist them in making drinking decisions in the future.

All subjects continued participation in the 'Alcohol Self-Control Program' concurrently with participation in the study. This self-control program involved group and individual training in the use of applied behavior analysis in reducing the severity of drinking habits. The training took place on an unlocked ward. No psychoactive drugs, including alcohol, were used routinely in the program. None of the experimental subjects received psychoactive drugs during participation in the study. Two subjects received short-term antibiotic and antihistamine therapy for minor respiratory tract infections.

One of the six subjects contracted for participation in the study left the hospital on the night following the fourth experimental session. The reason for attrition was reported as a need for a drink following a session in which a relatively high level of blood alcohol was produced (140 mg alcohol per 100 ml blood). None of the

remaining five subjects left the hospital for drinking-related reasons. There were four additional moderate to heavy drinking episodes among the remaining five subjects during the course of the study, although only one necessitated re-admission to the locked detoxification ward. All five of the remaining subjects completed the study.

Demographic information for the five subjects who completed the study is presented in Table 1. Included in that table are data relating to the severity of each subject's drinking history.

Alcoholic Beverages and Administration

Alcohol was given as distilled ethanol, 95 percent alcohol by volume (% v/v), diluted with grapefruit juice and ice. The range of dosages for experimental sessions was .50 to 2.26 g alcohol per kg body weight (g/kg), or 34.5 cc to 162.0 cc of 95% v/v ethanol. The mean dosage over all five subjects in experimental sessions was 1.241 g/kg. Subjects were administered alcoholic beverages between two and three hours post-meal, as a rule. Subjects were required to wear swimmer's nose-clips in order to reduce the effectiveness of olfaction in detecting drink concentration. Mouthwash (Cepacol ®) was swished thoroughly and spit out of the mouth immediately prior to and following each drink sip. Drinks were consumed from two eight-ounce opaque glasses, with each glass containing exactly one-half

TABLE 1

Demographic Data for Subjects Completing the Study

Subject	1	2	3	4	5
Age (years)	26	34	37	33	60
Education (years)	14	12	16	12	8
Occupation	Auto Body Repair	Textile Worker	Teacher	Truck Driver	Painter
Duration of Drinking Problem [a] (years)	2	15	17	9	10
Number Inpatient Hospitalizations[b]	0	13	1	0	26

[a] verbal report

[b] verbal report and hospital records

the dosage for that experimental session. Two glasses, or a total of 480 ml, were required in order to dilute the alcohol as effectively as possible, while keeping the fluid intake at a minimum. All subjects were instructed that alcohol was present in both drinks. Subjects were required to finish both glasses of alcoholic beverage within a five-minute period. Following drink administration, subjects were asked to rank the concentration of each glass on a scale of one to five, ascending as concentration increased.

Dosages were calculated initially on the basis of data presented by Aschan et al. (1956), who found a 1 to 100 relationship between grams alcohol per kg body weight and mg alcohol per 100 ml blood (mg/100 ml). Findings of generally lower levels of blood alcohol, however, in initial experimental sessions prompted increments in dosage in order to approximate the following levels: 40, 60, 80, 100, and 120 mg alcohol per 100 ml blood.

Measurement of Blood Alcohol

Levels of alcohol in the blood were assessed indirectly through the use of the Breathalyzer (Model 900A, Smith & Wesson Electronics Co., Eatontown, N. J.). Calibration of the Breathalyzer 900A was performed at frequent intervals throughout the experimental procedure, with a total of 20 calibrations collected. Calibration was achieved through

the use of a Mark II Simulator (Smith & Wesson Electronics Co., Eatontown, N. J.) and a 100 mg ethanol/100 ml stock solution, certified by the Smith & Wesson Electronics Co. (Eatontown, N. J.). Calibration readings varied between 90 and 100 mg ethanol/100 ml, with a mean of 94.4 mg/100 ml. Concurrent validity was assessed through the use of gas chromatography of actual blood samples available on only two days of the procedure. Three blood samples, taken from veins in the subjects' forearms, were assessed and compared with Breathalyzer recordings collected within ten minutes of the blood sample. Breathalyzer assessments of blood alcohol were found to underestimate consistently the actual blood assessments by approximately 30 mg/100 ml, with a range of 28 to 35 mg/100 ml below actual blood sample assessments for the three validity checks.

Nystagmography

Lateral eye movements were recorded by means of two silver ball electrodes, one placed at the outer canthus of each eye, and one silver cup electrode placed at the center of the forehead. Because the eyeballs act as bipolar systems, with a positive charge in the cornea and a negative charge in the retina, changes in their electrical potential through movement from side to side are picked up by the electrodes placed at the outer canthi. Two channels of a 16-channel electroencephalograph (Model 78B, Grass Instrument Co.,

Quincy, Mass.) were employed in the recording of lateral eye movements. Two channels were used as a safety precaution to reduce the liklihood of data loss through malfunctioning of a pen or amplifier in either channel. Each channel was set at a sensitivity of 7.5 μV/mm and the paper was run at a speed of 30 mm per second. Electrode leads were connected to the EEG by a Mini Electrode Board (Grass Instrument Co., Quincy, Mass.) so that leads could be disconnected and reconnected with ease. Following the production of a good erythma on the skin with an alcohol sponge, each electrode was attached to the subject with surgical tape and Medcream EEG electrode cream (Medcraft, Skippack, Pa.).

Recording periods began with a determination of cutaneous resistance over the electrodes through the use of an Electrode Impedance Meter (Grass Instruments Co., Quincy, Mass.). Impedances greater than 20 kilohms were corrected by re-application of electrodes. Recording channels on the EEG were then calibrated with a 50 μV impulse.

Each subject was placed on his back on a mobile stretcher that allowed supine as well as sitting body positions. Calibration of eye movements was performed by placing the subject in a sitting position, with eyes focused on one of two black circles on the wall directly in front of him. The stretcher was placed so that the

subject's eyes were 300 cm from the black targets. This distance produced a 10 degree arc of eye movement, represented by approximately 250 mm of pen movement on the EEG, when the eyes were moved laterally from one black target to the other. Calibration records were inspected before proceding with the actual recordings of baseline and post-drink eye movements.

Electrodes were always connected to the same terminals on the Mini Electrode Board so that polarity of the recording apparatus remained constant. Therefore, pen movements in an upward direction represented eye movements to the right, while downward pen movements represented eye movements to the left.

In PAN experimental sessions, nystagmus was recorded by instructing each subject to place his head on its side to either the right or left, with the subject lying on his back. The subject was instructed to look toward the middle of one of two plain black velvet targets, approximately 91.4 cm x 91.4 cm, 130 cm to either his right or left. During eye-open conditions, he was instructed to leave his eyes open and as stationary as possible, without actually focusing on any characteristic of the target. The subject was instructed not to blink unless necessary. In eyes closed, he was told to close his eyes while his head remained in a lateral position and to keep his eyeballs as steady as possible.

Room lighting was extinguished once the subject had received instructions and his head had been placed in the right or left lateral position of PAN sessions or the forward position of N-PAN sessions. Following the extinction of room illumination, tape recorded white noise was switched on to mask auditory stimulation and remained on throughout the recording period. Subjects were allowed approximately 15 seconds to adapt to each head (right-left) and eye (open-closed) position prior to the initiation of electronystagmographic recording.

During N-PAN experimental sessions, eye movements were recorded with the subject sitting up and staring straight ahead at a 91.4 cm x 91.4 cm black velvet target 130 cm from his eyes. Again, the subject was instructed to keep his eyeballs as stationary as possible, without blinking unless necessary. As in PAN, he was instructed not to focus on any part of the velvet, rather to look in that direction, In recording periods with eyes closed, each subject was instructed to close his eyes and maintain his head in the same forward position as in eyes open, as if he were continuing to stare at the black velvet target.

In both PAN and N-PAN experimental sessions, subjects were instructed to relax prior to recording eye movements. Internal stimuli that are relevant to positional alcohol nystagmus were described. Subjects were asked to attend to these sensations and to be able to report them verbally

following termination of the recording period. Instructions regarding attention to these stimuli were taken in part from Goldberg (1970) and were as follows:

> I want you to pay close attention to the sensations in and around your eyes, especially those feelings suggesting movements of your eyes. Also pay attention to more general sensations such as dizziness, nausea, and double vision, if present. I want you to be able to describe those sensations that you experience when you are finished.

These instructions were given in both PAN and N-PAN sessions.

Recording of eye movements in PAN sessions was approximately 30 seconds in duration for each head and eyes position -- that is, head right - eyes open, head right - eyes closed, head left - eyes open, head left - eyes closed. Thus, there was a total of approximately 120 seconds of actual recording per recording period. These durations varied somewhat because the level of lighting in the room was so low that it was impossible to use accurately the second hand of a watch.

In N-PAN sessions, recordings of eye movements were approximately 120 seconds in duration, with 60 seconds in both eyes-open and eyes-closed. Again, the low level of room illumination rendered difficult more precise timing of measurement periods.

Procedure

The design of the study required first that subjects be trained in estimation of blood alcohol in training sessions prior to investigation of the variable under consideration. Subsequently, the experimental manipulation consisted of allowing subjects five opportunities to estimate blood alcohol under each of two experimental conditions; i.e., the position of the subject's head and body. These opportunities were presented in discrete trials, with the order of the two experimental conditions randomized. Only one opportunity to estimate blood alcohol was programmed per experimental session. A third training session was presented between the fifth and sixth experimental sessions in order to assure asymptotic performance in accuracy of estimation of blood alcohol.

Training Sessions. The six original subjects were divided into two groups of three subjects each. The two groups were then run on alternate days so that subjects had more than 40 hours between the termination of one drinking session and the initiation of the next. This interval was chosen because of findings of Nsamba and Al-Marashi (1972), on the basis of which those authors recommended that at least 30 hours intervene between a drink and baseline recordings for spontaneous nystagmus. Thus, it was felt that 40 hours represented a safe interval between sessions -- that is, one in which the effects of

the previous drinking of alcoholic beverages would no longer be exerting influence over eye movements in a subsequent session. Subjects were lagged within each of the two groups because of the lengthy duration of training sessions for each subject, i.e., approximately three to four hours. Thus, each group began with two members, with the third added after the two training sessions had been completed for the first two. Hence, the first experimental session for two subjects in each group concurred with the first training session for the third subject.

Training sessions consisted of between four and six opportunities for each subject to drink, receive feedback for positional alcohol nystagmus, estimate blood alcohol, and receive feedback from the Breathalyzer for actual blood alcohol. Subjects received the following total opportunities for the above sequences over all three training sessions: Subject 1 = 15; Subject 2 = 14; Subject 3 = 13; Subject 4 = 16; Subject 5 = 14.

During training sessions, subjects reported to the Electroencephalography Laboratory, across the street from their quarters, immediately subsequent to the noon meal. Electrodes were applied and calibrations of the EEG and lateral eye movements were performed. Each subject was then placed in a PAN position, previously described, and baseline recordings of eye movements were taken in all four positions, i.e., head right - eyes open, head right - eyes

closed, head left - eyes open, head left - eyes closed. The subject was then asked to report the sensations he had just experienced in and around his eyes, and more generally throughout his body, which resulted from being placed in each position.

The actual nystagmographic records were shown to the subject. Nystagmus, when present, was pointed out in an attempt to correlate sensations while in the recording position with objectively observed eye movement.

The subject was then asked to estimate his level of blood alcohol (presumably zero) on the basis of the following instructions:

> I want you to accurately estimate your blood alcohol level on the basis of a scale between zero and fifteen. Zero represents the level of alcohol in your blood when you have had nothing to drink for several hours. Five represents the level produced by two or three beers drunk in rapid succession. Ten represents the blood alcohol level produced by about five or six ounces of whiskey drunk in a short period of time. Fifteen represents the level of alcohol produced by a little more than a half-pint of whiskey drunk straight down. As accurately as possible, estimate your present blood alcohol on the basis of that scale using whole or half numbers.

Initial levels of alcohol in the blood were consistently zero, or slightly but nonsignificantly above that. Thus, it is likely that no subject had consumed significant quanties of alcoholic beverages within two to three hours prior to initiation of any training session, according to obtained Breathalyzer readings.

Following the baseline estimation of blood alcohol, the subject was returned to a sitting position on the mobile stretcher and moved to an office adjoining the Electroencephalography Laboratory. At this point, an assistant administered the alcoholic beverage, previously calculated on the basis of the subject's weight, taken earlier that day, and the approximate level of blood alcohol desired. Enough ethanol was administered initially to produce blood alcohol levels of between 20 and 50 mg/100 ml. Following consumption of the beverage, the subject was cautioned not to move significantly his body, head, or eyes while remaining in a sitting position on the mobile stretcher. He was instructed to keep his eyes open. The experimental assistant monitored each subject constantly. A recorded tape consisting of intermittent audio tones against a constant white noise background was started. The tone, 2000 cps, had been recorded from a BRS Audio-Oscillator and was of randomly varying amplitude. Subjects were instructed to raise their right hands in response to each tone in order to assess attention by subjects to verbal instructions by the experimenters. They were situated so that no one could observe another raise his hand in response to a tone. The experimental assistant recorded, concurrently, the occurrences of tones and each subject's hand raising. The assistant continuously monitored subjects over the intervals between drink administration and estimation of blood alcohol.

The subject was returned on the mobile stretcher to the laboratory 30 - 40 minutes following drink administration. There, the entire calibration, nystagmus recording, estimation of blood alcohol, and feedback of actual blood alcohol was repeated. As in baseline, the subject was given nystagmographic feedback following his verbal report of sensations experienced in recording sessions.

The subject was pushed back into the adjoining room and drink administration was repeated, this time with another dosage of ethanol. Dosages in training sessions were calculated so that a level of alcohol in the blood of between 100 and 150 mg/100 ml would be achieved following the last dosage. The procedure was repeated between four and six times per training session.

Throughout the training session, the subject remained on the mobile stretcher. Only when urination was necessary did the subject move, and then only to sit on the edge of the stretcher and micturate into a hospital urine receptable.

At the end of each session, each subject was accompanied back to the ward, where ward personnel were instructed to provide him with supper. Subjects were carefully monitored by ward personnel for the remainder of the evening.

Although, initially, it was intended that subjects were to reach an asymptotic criterion for deviation scores

of equal to or less than ± 15 mg/100 ml, the unexpectedly long duration of training sessions led to the use of a time requirement of two training sessions prior to experimental sessions and one training session between the fifth and sixth experimental sessions. Subjects had become extremely uncomfortable during training sessions, to the point where their attrition was threatened and, in the investigator's opinion, highly probable.

Experimental Sessions. PAN sessions were identical to training sessions with the following exceptions: 1) sessions were initiated between 2½ and 3 hours following the noon meal; 2) no feedback from the nystagmographic recordings was provided to subjects; 3) only one drink administration and feedback to actual blood alcohol was performed, with approximately 90 minutes intervening between drink administration and the initiation of nystagmus recording and, therefore, approximately 120 minutes between the drink and measurement of actual blood alcohol; and 4) levels of alcohol in the blood for each session were calculated to be either 40, 60, 80, 100, or 120 mg/100 ml.

One of the five pre-calculated values for blood alcohol was randomly assigned prior to each PAN session. Pre-calculated values of blood alcohol were balanced across PAN sessions with each of the five values appearing once.

N-PAN sessions were identical to PAN sessions with the exception that subjects were placed in the N-PAN

recording position during nystagmus recording periods. This body position served as a control for the experimental body position used in PAN sessions.

PAN and N-PAN sessions were randomly assigned to the ten experimental days, with the exception that five of each be performed for each subject.

CHAPTER III

RESULTS

Dosage and Level of Blood Alcohol

Average dosages and resultant levels of alcohol in the blood are presented in Table 2 for each subject. Additionally, mean times between dosages and measures of alcohol in the blood, and mean blood levels of alcohol produced by unit dose (1g/kg) are presented in Table 2. For each subject, mean blood alcohol per unit dose was calculated by using mean blood alcohol levels achieved as the numerator and mean dosages administered as the denominator.

It can be seen that while dosage levels were equivalent, levels of alcohol in the blood varied considerably between subjects, thereby generating different means for blood alcohol per unit dose. Thus, rates of absorption and elimination were seen to vary among subjects in this experiment, even though the mean numbers of minutes between dosage and measurement of alcohol in the blood were approximately equal.

The BAL/unit dose ratios for the present investigation, seen in Table 2, were ostensibly considerably lower than that calculated from data presented by Aschan et al. (1956). This finding is consistent with the discrepancies of approximately 30 mg/100 ml found, in this study between

TABLE 2

Mean Alcohol Dosage, Blood Alcohol Levels (BAL)[a], Times Between Dosage and BAL Measurement, and BAL per Unit Dose for Each Subject Over the Ten Experimental Sessions

Subject	Mean Dosage[b]	Mean BAL[c]	Interdosage Time (min.)	BAL/ Unit Dose
1	1.244	90.0	114.5	72.35
2	1.241	72.8	111.2	58.66
3	1.212	85.3	110.6	70.38
4	1.263	81.5	111.2	64.53
5	1.246	77.1	118.2	61.88

[a] Breath analyses via Breathalyzer

[b] (g alcohol/kg body weight)

[c] (mg alcohol/100 ml blood)

blood alcohol analyses performed with breath samples and those with actual blood samples. Aschan et al. (1956) employed the Widmark micro method of blood alcohol analysis, a procedure involving the withdrawal of blood and subsequent titration with a bichromate solution and, finally, an iodometric retitration. Hence, the BAL/unit dose ratios found in the present study would have been consistent with ratios calculated from Aschan et al. (1956), had actual blood analysis rather than breath analysis been employed.

Scoring and Reliability for Nystagmus Measures

Nystagmus. Lateral eye movements were recorded on one channel of a 16-channel EEG. Two scorers, Scorer 1 and Scorer 2, were instructed independently in identifying positional alcohol nystagmus. Scorers were directed to score any rapid pen movement not having the topography of an eye blink or facial muscle twitch; therefore, nystagmic events were defined as relatively straight lines, in either vertical direction, indicating a range of approximately 2 - 10 degrees of eye movement through the visual field. Horizontal straight lines represented periods during which the recording electrode leads were disconnected from the pens. The distance that the pen had travelled, either up or down, with respect to the overall recording for each subject in each session was the critical feature in scoring nystagmus. Pen movements of great magnitude, often

suggesting more than 15 degrees of lateral eye movement through the visual field, were defined as artifactitious eye movement, blinking, or facial muscle disturbances. Clinical observation during sessions confirmed that extremely high frequency activity in the pen indicated clenching of the jaws. Scorers were instructed not to score such recordings. Scoring was accomplished by each scorer independently considering each subject's total record, both pre-drink and post-drink, for each session. Thus, scoring of post-drink records was done with respect to each subject's pre-drink record in order to assess the magnitude of change due to alcohol.

Rapid pen marks in an upward direction were known to represent eye movements to the right; those in a downward direction represented eye movements to the left. For PAN data, the number of nystagmic movements to the left was subtracted from the number to the right, and the remainder was divided by the total number of seconds of recording scored. The resultant score, positive for predominantly right movement and negative for predominantly left movement, was in units of beats in the predominant direction per second, herein referred to as "beats per second." Beats per second from the pre-drink recordings were subtracted from beats per second from the post-drink recordings for each scorer in each head position. Finally, beats per second were averaged over both head positions and

scorers. The resultant rate was assumed to represent the change in lateral eye movements attributable to the dose of alcohol administered in between recording periods. Thus, a nystagmus change score of 3.0 beats per second indicates an intense positional alcohol nystagmus (PAN I). A low positive or negative change score represents weak or absent positional alcohol nystagmus. A high negative change score indicates PAN II, a post-intoxication phenomenon, which consists of rapid eye movements occurring in the lateral direction opposite the direction in which the head is turned.

Because recordings during eyes-closed were found to be highly variable and difficult to score, only recordings during eyes-open were used in further analyses.

In summary, the nystagmus change scores indicate the extent to which rapid eye movements were in the same direction as the head position in the post-drink recording period in comparison with the directionality of eye movements with respect to head position in appropriate pre-drink recording periods. Only eyes-open positions were used in the nystagmus calculations. Final nystagmus change scores represent the average of two independent scorers' assessments of the same records and the average of beats per second in the left and right head positions. Nystagmus change scores during PAN sessions are presented for each subject over each session in Tables 3 - 7.

TABLE 3

Nystagmus Scores[a] in Beats per Second in Predominant Direction, and Verbal Description of Nystagmus Scores[a] for Subject 1 in PAN

Head Position	Recording Period[b]	PAN Session 1	2	3	4	5
		Nystagmus				
Rt.	Pre-	.10-lf	.12-rt	.20-lf	.02-lf	.06-rt
	Post-	.78-rt	.16-rt	.14-rt	1.66-rt	.80-rt
Lf.	Pre-	.04-rt	.16-rt	.08-lf	.06-rt	.08-rt
	Post-	.50-lf	.06-rt	.08-lf	1.10-lf	.30-lf
Change Score[c]		+.71	+.07	+.17	+1.40	+.56
		Verbal Description of Nystagmus				
	Pre-	1.0	0.0	1.0	5.0	1.0
	Post-	6.5	1.5	4.5	7.5	5.5
Change Score[c]		+5.5	+1.5	+3.5	+2.5	+4.5
Blood Alcohol Level (mg alcohol/ 100 ml blood)		100	20	35	123	99

[a] Each score represents the mean of two independent scorers.

[b] Pre = prior to consuming drink
Post = subsequent to consuming drink

[c] See text for explanation of scoring procedure.

TABLE 4

Nystagmus Scores[a] in Beats per Second in Predominant Direction, and Verbal Description of Nystagmus Scores[a] for Subject 2 in PAN

Head Position	Recording Period[b]	PAN Session 1	2	3	4	5
		Nystagmus				
Rt.	Pre-	.04-rt	.04-lf	.01-rt	.07-rt	.04-rt
	Post-	.83-rt	.16-rt	.47-rt	.30-rt	.15-rt
Lf.	Pre-	.10-lf	.08-lf	.02-rt	.09-rt	.04-rt
	Post-	.44-lf	.42-lf	1.44-lf	.60-lf	.04-lf
Change Score[c]		+.56	+.27	+.96	+.46	+.10
		Verbal Description of Nystagmus				
	Pre-	1.5	2.0	4.0	1.0	8.0
	Post-	7.0	10.5	5.0	13.5	9.0
Change Score[c]		+5.5	+8.5	+1.0	+12.5	+1.0
Blood Alcohol Level (mg alcohol/ 100 ml blood)		107	59	100	87	20

[a] Each score represents the mean of two independent scorers.

[b] Pre = prior to consuming drink
Post = subsequent to consuming drink

[c] See text for explanation of scoring procedure.

TABLE 5

Nystagmus Scores[a] in Beats per Second in Predominant Direction, and Verbal Description of Nystagmus Scores[a] for Subject 3 in PAN

Head Position	Recording Period[b]	PAN Session 1	2	3	4	5
		Nystagmus				
Rt.	Pre-	[d]	.08-rt	.05-rt	.04-rt	.05-rt
	Post-	[d]	.46-rt	1.60-rt	2.44-rt	1.97-rt
Lf.	Pre-	.15-rt	.80-rt	.12-rt	.20-rt	.16-rt
	Post-	1.09-lf	.68-lf	1.75-lf	2.20-lf	1.46-lf
Change Score[c]		[d]	+.93	+1.71	+2.40	+1.77
		Verbal Description of Nystagmus				
	Pre-	[d]	8.5	9.0	7.5	6.0
	Post-	[d]	6.5	15.5	14.0	8.0
Change Score[c]		[d]	-2.0	+6.5	+6.5	+2.0
Blood Alcohol Level (mg alcohol/ 100 ml blood)		75	36	79	115	111

[a] Each score represents the mean of two independent scorers.

[b] Pre = prior to consuming drink
Post = subsequent to consuming drink

[c] See text for explanation of scoring procedure.

[d] Missing data

TABLE 6

Nystagmus Scores[a] in Beats per Second in Predominant Direction, and Verbal Description of Nystagmus Scores[a] for Subject 4 in PAN

Head Position	Recording Period[b]	PAN Session 1	2	3	4	5
		Nystagmus				
Rt.	Pre-	.03-rt	.01-lf	.02-rt	.14-lf	.04-rt
	Post-	.54-rt	.37-rt	.93-rt	.26-rt	.82-rt
Lf.	Pre-	.08-rt	.08-lf	.09-lf	.05-rt	.06-lf
	Post-	1.28-lf	.69-lf	.86-lf	.60-lf	.79-lf
Change Score[c]		+.94	+.50	+.84	+.52	+.76
		Verbal Description of Nystagmus				
	Pre-	5.5	4.5	7.0	4.0	7.0
	Post-	3.5	11.0	12.5	15.0	15.0
Change Score[c]		-2.0	+6.5	+4.5	+11.0	+8.0
Blood Alcohol Level (mg alcohol/ 100 ml blood)		110	80	81	65	92

[a] Each score represents the mean of two independent scorers.

[b] Pre = prior to consuming drink
Post = subsequent to consuming drink

[c] See text for explanation of scoring procedure.

TABLE 7

Nystagmus Scores[a] in Beats per Second in Predominant Direction, and Verbal Description of Nystagmus Scores[a] for Subject 5 in PAN

Head Position	Recording Period[b]	PAN Session 1	2	3	4	5
		Nystagmus				
Rt.	Pre-	.10-lf	.02-rt	.13-rt	.03-rt	.14-rt
	Post-	1.36-rt	2.22-rt	.06-rt	.09-rt	.20-rt
Lf.	Pre-	.70-rt	.73-rt	.63-rt	.40-rt	.65-rt
	Post-	.02-rt	.40-lf	.05-rt	.23-rt	.07-rt
Change Score[c]		+1.07	+1.66	+.26	+.12	+.32
		Verbal Description of Nystagmus				
	Pre-	6.0	3.0	5.0	5.0	4.5
	Post-	10.0	7.0	3.0	7.0	7.0
Change Score[c]		+4.0	+4.0	-2.0	+2.0	+2.5
Blood Alcohol Level (mg alcohol/ 100 ml blood)		130	110	39	57	70

[a] Each score represents the mean of two independent scorers.

[b] Pre = prior to consuming drink
Post = subsequent to consuming drink

[c] See text for explanation of scoring procedure.

Scoring of eye movements in N-PAN sessions was identical to scoring in PAN sessions, except for the omission of directionality of the eye movements. This omission was due to the nature of N-PAN sessions in which subjects looked straight ahead at all times, thereby making direction of eye movements unpredictable. Eye movement change scores in N-PAN sessions were computed by adding the frequencies of pen marks indicating movements to both the left and right, dividing by the number of seconds of the record, and averaging across the two scorers. Finally, pre-drink rates of lateral eye movements were subtracted from post-drink rates in order to obtain a change score reflecting the influence of the drink on eye movement. Hence, N-PAN change scores represent differences between pre-drink and post-drink in the number of lateral eye movements per second, both in the right and left directions, averaged across the two scorers. Change scores for nystagmus in N-PAN sessions are presented in Tables 8 - 12.

Reliability between the scorers for nystagmus change scores for both PAN and N-PAN sessions was calculated by correlating the scorers' assessments of pre- to post-drink change over each session for each subject. Figure 1 presents the distributions of reliability coefficients for each of the five subject's nystagmus change scores over PAN and N-PAN sessions. While reliability coefficients were

TABLE 8

Nystagmus and Change Scores in Total Beats per Second and Verbal Description of Nystagmus for Subject 1 in N-PAN[a]

Recording Period	N-PAN Session				
	1	2	3	4	5
	Actual Nystagmus				
Pre-Drink	.46	.24	.26	.12	.36
Post-Drink	.63	.26	.33	.52	.98
Change Score	+.17	+.02	+.17	+.40	+.62
	Verbal Description of Nystagmus				
Pre-Drink	4.0	1.5	2.0	3.0	0.0
Post-Drink	2.0	5.0	6.0	3.0	3.5
Change Score	-2.0	+3.5	+4.0	0.0	+3.5
Blood Alcohol Level (mg alcohol/ 100 ml blood)	121	120	72	120	90

[a] Each score represents the mean of two independent scorers.

TABLE 9

Nystagmus and Change Scores in Total Beats per Second and Verbal Description of Nystagmus for Subject 2 in N-PAN[a]

Recording Period	N-PAN Session				
	1	2	3	4	5
	Actual Nystagmus				
Pre-Drink	.14	.14	.03	.06	.06
Post-Drink	.25	.24	.23	.04	.27
Change Score	+.11	+.10	+.20	-.02	+.21
	Verbal Description of Nystagmus				
Pre-Drink	2.5	4.0	1.0	3.5	3.0
Post-Drink	5.5	1.0	4.0	8.0	4.5
Change Score	+3.0	-3.0	+3.0	+4.5	+1.5
Blood Alcohol Level (mg/alcohol 100 ml blood)	25	85	28	140	77

[a] Each score represents the mean of two independent scorers.

TABLE 10

Nystagmus and Change Scores in Total Beats per Second and Verbal Description of Nystagmus for Subject 3 in N-PAN[a]

Recording Period	N-PAN Session				
	1	2	3	4	5
	Actual Nystagmus				
Pre-Drink	.86	1.08	1.68	1.16	1.33
Post-Drink	1.53	1.86	1.48	.57	1.55
Change Score	+.67	+.78	-.20	-.59	+.22
	Verbal Description of Nystagmus				
Pre-Drink	7.0	5.5	7.5	7.0	6.5
Post-Drink	3.0	4.5	3.5	9.5	4.5
Change Score	-4.0	-1.0	-4.0	+2.5	-2.0
Blood Alcohol Level (mg alcohol/ 100 ml blood)	115	62	170	32	58

[a] Each score represents the mean of two independent scorers.

TABLE 11

Nystagmus and Change Scores in Total Beats per Second and Verbal Description of Nystagmus for Subject 4 in N-PAN[a]

Recording Period	N-PAN Session				
	1	2	3	4	5
	Actual Nystagmus				
Pre-Drink	.42	1.50	.99	.56	.98
Post-Drink	1.11	1.34	.73	.79	1.27
Change Score	+.69	-.16	-.26	+.23	+.29
	Verbal Description of Nystagmus				
Pre-Drink	6.0	0.0	1.5	3.5	2.5
Post-Drink	7.5	3.5	7.0	3.5	5.5
Change Score	+1.5	+3.5	+5.5	0.0	+3.0
Blood Alcohol Level (mg alcohol/ 100 ml blood)	158	27	91	81	30

[a] Each score represents the mean of two independent scorers.

TABLE 12

Nystagmus and Change Scores in Total Beats per Second and Verbal Description of Nystagmus for Subject 5 in N-PAN[a]

Recording Period	N-PAN Session				
	1	2	3	4	5
	Actual Nystagmus				
Pre-Drink	.60	.16	.28	.26	.59
Post-Drink	.68	.20	.22	.27	.40
Change Score	+.08	+.04	-.06	+.01	-.19
	Verbal Description of Nystagmus				
Pre-Drink	1.0	4.0	2.5	2.0	2.5
Post-Drink	2.5	4.0	5.0	4.5	6.5
Change Score	+1.15	0.0	+2.5	+2.5	+4.0
Blood Alcohol Level (mg alcohol/ 100 ml blood)	23	65	91	98	88

[a] Each score represents the mean of two independent scorers.

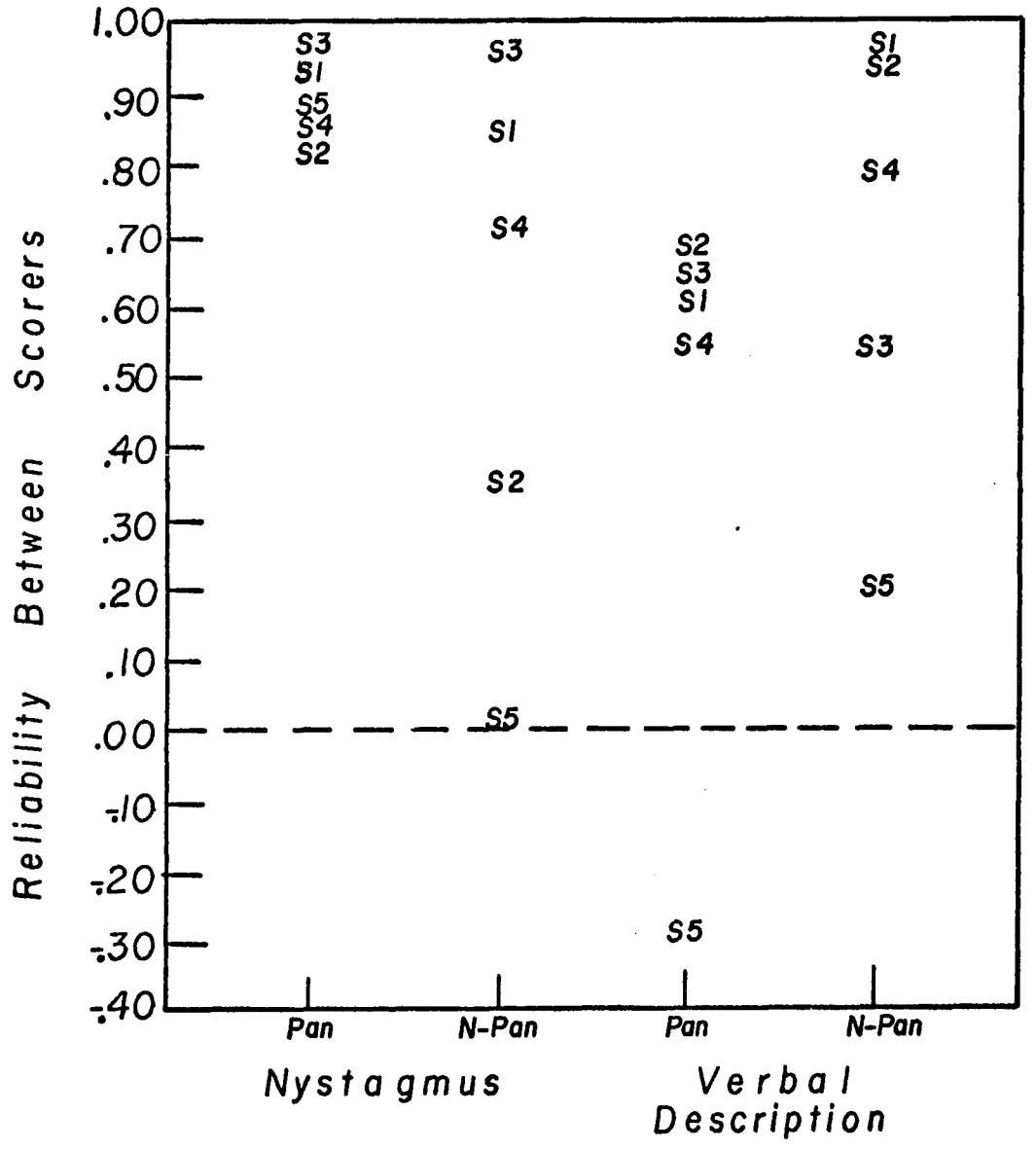

Figure 1. Reliability Between Scorers for Nystagmus and Verbal Description of Nystagmus in PAN and N-PAN Sessions for Each Subject

all above .80 between scorers' assessments in PAN sessions, reliability was more variable in N-PAN sessions, varying between +.01 (Subject 5) and +.97 (Subject 3). Hence, in this investigation, change scores for positional alcohol nystagmus were consistently reliable while change scores for eye movement in N-PAN sessions were not.

Verbal description of nystagmus. Verbal reports of private events occurring during nystagmus recording periods in both PAN and N-PAN sessions were initially recorded by the experimenter and, later, transcribed onto summary sheets for scoring. Scorers 3 and 4 were instructed to assign numerical values to verbs and modifiers which implied the occurrence of eye-movement and nystagmus. Verbs were given values of between zero and three, while modifiers were assigned values of between zero and two, each according to the quality and intensity of nystagmus inferred. Included in the definition of nystagmus were verbs that described minor visual disturbances (score = 1), movement of the eyeballs or muscles controlling them (score = 2), and systemic concomitants of severe nystagmus, such as dizziness and nausea (score = 3). Excluded were verbs that described activity outside of the eye, such as twitching of the cheek, etc. (score = 0). Modifiers were assigned values on the basis of strength implied, varying between "no" (score = 0) and "severe" (score = 2).

The value for each verb was multiplied by the value of its respective modifier in order to arrive at a total score for the particular sensation unit being described. Scores for each sensation unit were then added within each pre-drink and post-drink record. Change scores for each experimental session were calculated by subtracting each pre-drink total from each post-drink total score. Scoring was done independently of knowledge of experimental conditions, drug levels, or pre-drink and post-drink recording period status. Final change scores represent the mean of the two scorers' assessments. Verbal description and change scores are presented in Tables 3 - 7 for PAN sessions and Tables 8 - 12 for N-PAN sessions.

Reliability coefficients between scorers' assessments of verbal description of nystagmus were calculated by correlating scorers' numerical scores for change between pre- and post-drink over each session for each subject. Figure 1 presents the distributions of reliability coefficients for each of the five subject's verbal description change scores over PAN and N-PAN sessions. As in the case of N-PAN scores for nystagmus, reliability was variable over all five subjects for both PAN and N-PAN verbal description scores. Thus, the objectivity of these verbal report data is subject to question at this time, with differing objectivity across subjects in this study.

Actual Nystagmus and Levels of Blood Alcohol

A central assumption of this investigation requires that a strong positive relationship obtain between levels of alcohol in the blood and the rate of rapid eye movement in the direction of the head turn in PAN sessions. Coefficients of correlation between the nystagmus change scores and terminal blood alcohol values, presented in Tables 3 - 7, revealed the following strengths of association for each subject: Subject 1, $r = .91$; Subject 2, $r = .85$; Subject 3, $r = .92$; Subject 4, $r = .79$; Subject 5, $r = .83$. All correlations but that of Subject 4 are significant ($p < .05$; $df = 4$).

Equally important, on the other hand, is the assumption that the control condition for body position (N-PAN) generates no regular and high relationship between levels of blood alcohol and absolute rate of eye movement. The Pearson coefficients for these data, presented in Tables 8 - 12, are as follows: Subject 1, $r = .26$; Subject 2, $r = .63$; Subject 3, $r = .06$; Subject 4, $r = .57$; Subject 5, $r = -.81$. None of these correlations is significant statistically ($p < .05$; $df = 4$).

Comparisons of strengths of association for PAN and N-PAN relationships between nystagmus or eye movement and blood alcohol were consistent generally with the assumptions upon which this investigation was predicated. That is, during PAN sessions, variability in lateral

eye movements was explained to a high degree by levels of alcohol in the blood; during N-PAN, little consistent relationship across subjects existed between eye movement and blood alcohol. No statistically significant relationships between blood alcohol and eye movement in N-PAN sessions were noted within subjects.

Reference to Figure 1, showing reliability of scoring for PAN and N-PAN eye movement, and to the above strengths of association reveals little relationship between reliability of scoring and the correlation between nystagmus and blood alcohol. The exception to this statement is found in the nystagmus data for the two subjects (Subjects 1 and 3) who exhibited the highest rates of change in PAN eye movement. High reliability of scoring for these subjects was most likely a function of the occurrence of unequivocal and regular lateral eye movements. In N-PAN data, the highest nystagmus-blood alcohol relationship (r= -.81) occurs for the subject (Subject 5) with the poorest reliability of scoring (r= .01). Thus, it is unlikely that variability in relationships between nystagmus and blood alcohol were generated by scoring error in this study.

Estimated and Actual Drink Strength

Estimations of drink strength were made by each subject following consumption of each dosage at the beginning

of experimental sessions. Estimations were made verbally by forcing subjects to assign "strong," "medium," or "weak" to the contents of each of two standard-sized glasses. The adjectives strong, medium, and weak were assigned, subsequently, values of five, three, or one, respectively, and the scores for the two glasses were averaged over each experimental session for each subject. Thus, if a subject responded to the first glass with "strong" and the second with "medium," his score for estimated drink strength was four. The strength of association between alcohol doses and estimations of drink strength for each subject was calculated using the Pearson Product-Moment Coefficient. This coefficient was squared in order to estimate the percent of variance in estimated drink strength that is explained by dosage. The obtained strengths of association were highly variable, fluctuating between 98.2% (Subject 1 in PAN) and 5.8% (Subject 4 in N-PAN) as can be seen in Table 13. Subjects clearly demonstrated highly variable skills at discriminating between the strengths of alcoholic drinks used in this study.

Accuracy of Estimation in PAN and N-PAN Sessions

The deviations between each estimation and the actual blood alcohol value are presented for all subjects in Table 14. Each deviation score is given with its sign, that is, information concerning direction of the error. If no

TABLE 13

Strength of Relationship Given as Pearson Product-Moment Coefficient of Correlation Between Alcohol Dose and Estimation of Drink Strength for Each Subject Over PAN and N-PAN Sessions

	PAN		N-PAN	
Subject	r	$100r^2$	r	$100r^2$
1	.9908 *	98.2%	.5998	36.0%
2	.5401	29.2%	.9048 *	81.9%
3	.2887	8.3%	.7428	55.2%
4	.3133	9.8%	-.2412	5.8%
5	.8434	71.1%	.6207	38.5%

* $p < .05$; $df = 3$.

TABLE 14

Raw Deviations and Means[a] Between Estimated and Actual Blood Alcohol Levels, in Mg of Alcohol per 100 Ml of Blood

	Experimental Condition	
Subject	PAN	N-PAN
1	0, 0, 5, -3, 6 Mean = 2.8	-6, -35, -7, -10, 20 Mean = 15.6
2	-27, -19, -45, -17, 18 Mean = 25.2	35, -20, 0, -40, -2 Mean = 19.4
3	0, -6, 6, -25, -11 Mean = 9.6	-105, -32, -40, 13, -8 Mean = 39.6
4	-7, 20, 4, 15, 8 Mean = 10.8	-38, -17, 9, -41, -10 Mean = 23.0
5	-85, -60, 11, 33, 0 Mean = 37.8	27, -15, -41, -48, -18 Mean = 29.8

[a] Mean deviation score disregards sign, as do all further calculations concerning deviation scores.

sign precedes the deviation, the error is in the direction of an overestimate; if a minus precedes, the error is one of underestimation. Means are presented for each subject for all sessions within each experimental condition, PAN and N-PAN. As documented in Table 14, means for PAN and N-PAN deviation scores were calculated without regard for sign.

A 2-way analysis of covariance was performed on the deviation scores for all subjects, with experimental conditions and subjects serving as fixed variables. Sessions were nested within experimental conditions and subjects. Actual levels of alcohol in the blood served as the covariate because of the distinct possibility that deviation scores varied as a function of blood alcohol. Because terminal levels of blood alcohol could not be varied systematically for each subject, due to varying empirical dosage to blood alcohol functions, subjects' ranges and central tendencies for actual blood alcohol varied considerably. Cell means for deviation scores were adjusted for actual levels of blood alcohol and are presented in Table 15. Only "with" rows of Table 15, indicating that the analysis was performed with the data of Subject 5 included, are relevant at this point. A brief comparison between Tables 15 and 14 will reveal changes in cell means caused by the partialling-out of variance due to actual blood alcohol. A source table for the analysis of covariance on

TABLE 15

Adjusted Cell Means[a] of Deviation Between Estimates and Actual Blood Alcohol Levels, in Mg of Alcohol per 100 Ml of Blood for Subjects in PAN, and N-PAN, With and Without Subject 5

	Experimental Condition	
Subject	PAN	N-PAN
1		
With	4.2	9.98
Without	4.9	11.52
2		
With	26.84	21.90
Without	26.64	21.51
3		
With	9.15	38.14
Without	9.45	38.68
4		
With	9.77	23.95
Without	10.21	23.92
5		
With	37.83	31.82
Without	—	—

[a] Cell means adjusted for relationship between absolute blood alcohol level and accuracy of estimation.

deviation scores, using actual blood alcohol as a covariate, is presented in Table 16. Again, only the portion of the table referring to "with Subject 5" is relevant at this time. The fixed variable 'subjects' was significant, $F(4,39) = 3.326$, $p < .05$. Neither 'experimental conditions' nor the 'interaction' term reached the .05 level of confidence. Utility indices, calculated for both fixed variables and the interaction term, were as follows: Experimental Conditions = 2.1%; Subjects = 14.9%; Experimental Conditions x Subjects = 4.5%. Thus, while 'subjects' explained more of the variance in deviation scores than either of the other variables, its strength of association with the dependent variable was of little value in explaining accuracy of estimation under the present conditions. A Newman-Keuls post-hoc analysis of the 'subjects' variable revealed significant differences between Subject 1 and Subjects 2, 3, and 5, as well as between Subject 4 and 5. The summary for this analysis, presented in Table 17, suggests that Subject 1 and, to a lesser extent, Subject 4 were more accurate than the remaining three subjects in estimating blood alcohol. This finding, however, uses deviation scores pooled across PAN and N-PAN experimental conditions. The major problem for examination in this study concerns the role of experimental conditions in generating differential accuracies of estimation.

TABLE 16

Analysis of Covariance[a] on Deviations Between Estimated and Actual Blood Alcohol, With and Without Subject 5

Source	df	MS	F
With Subject 5			
Experimental Conditions (T)	1	719.43	2.318
Subjects (S)	4	1032.20	3.326 *
S x T	4	528.60	1.703 **
Observations (nested within ST)	39	310.35	
Without Subject 5			
Experimental Conditions (T)	1	1271.41	4.778 *
Subjects (S)	3	585.68	2.201 **
S x T	3	510.32	1.918 **
Observations (nested within ST)	31	266.08	

[a] Actual blood alcohol levels served as covariate.

* $p < .05$.

** $p < .20$.

TABLE 17

Newman-Keuls Post-Hoc Analysis of Significant Subjects Variable from Analysis of Covariance with Subject 5, Using Cell Totals Adjusted for Actual Blood Alcohol

Order					
	Subject 1 71.06	Subject 4 168.61	Subject 3 236.42	Subject 2 243.65	Subject 5 348.25
			Differences		
Subjects	1	4	3	2	5
1		97.6	165.4*	172.6*	277.2*
4			67.8	75.0	179.6*
3				7.2	111.8
2					104.6
5					
			Steps Between Totals		
Critical Values		2	3	4	5
$q_{.95}(5,39)$		2.86	3.45	3.80	4.05
$q_{.95}(\sqrt{nMS_{error}})$		112.66	135.90	149.69	159.54

*$p < .05$.

Figure 2 presents the estimation and actual blood alcohol data for Subject 5. A strong positive relationship can be seen between error in estimation and levels of alcohol in the blood. All but one of this subject's estimates over the first seven experimental sessions was 50 mg alcohol per 100 ml blood. Because these constituted relatively low estimates in respect to the range being tested (0-150 mg/100 ml), the correlation between accuracy and blood alcohol must be considered spurious. It is likely that this subject was responding from a strongly biased set over the initial seven sessions. This liklihood renders questionable the validity of this subject's estimates with respect to the purpose of this experiment.

Two additional factors cast doubt on the validity of the data generated by Subject 5. In Table 7, attention to the row presenting actual nystagmus scores during the left head-turn position in the pre-drink record reveals relatively high levels of nystagmus in the direction opposite the head turn. This suggests the occurrence of PAN II, a post-intoxication phenomenon. According to Aschan et al. (1956), when dealing with moderate levels of intoxication, PAN II begins prior to or following return of blood alcohol to zero and lasts for up to 12 hours. Hence, it is conceivable that levels of nystagmus in the direction opposite the head turn found for Subject 5

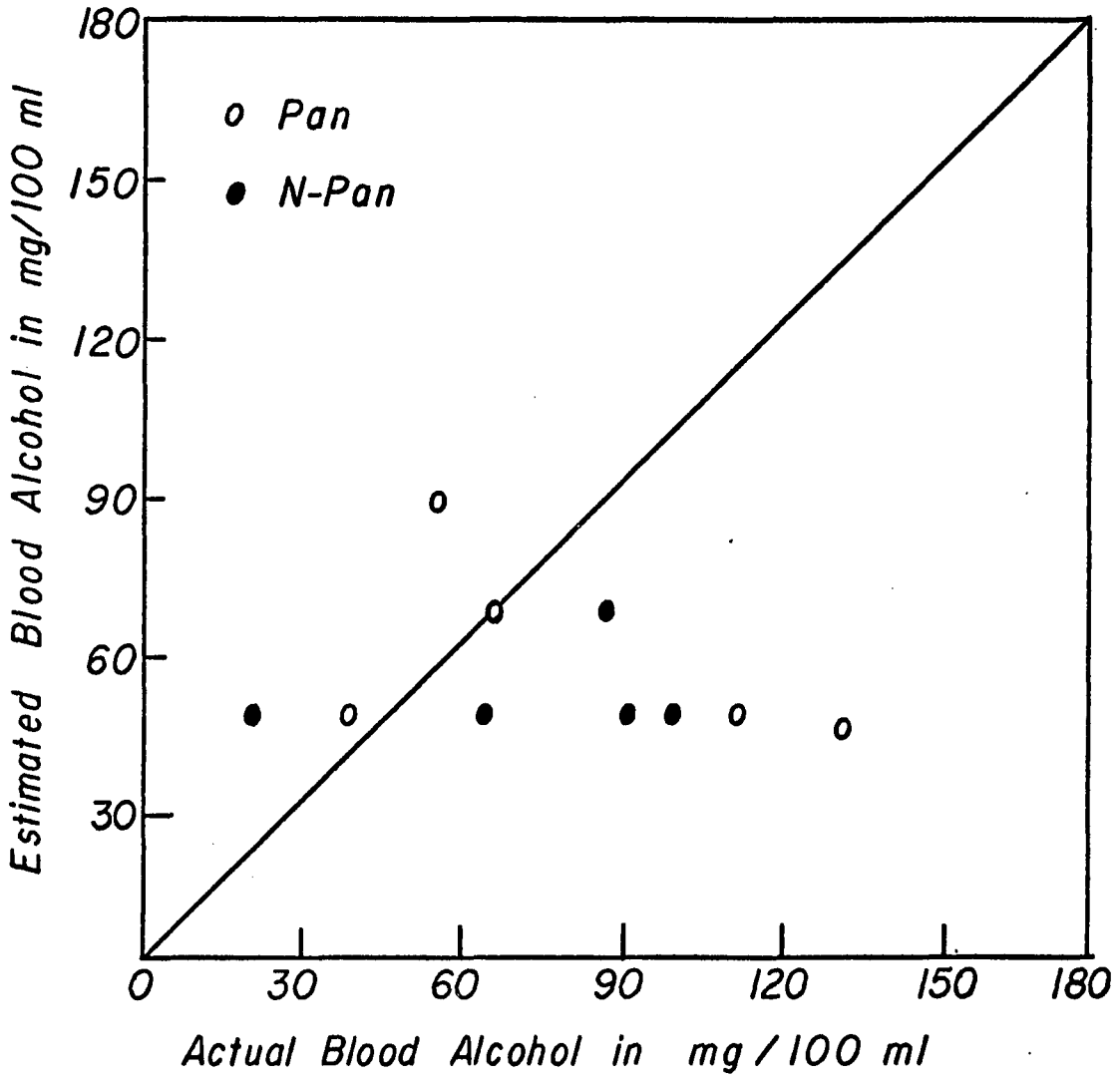

Figure 2. Estimated Blood Alcohol as a Function of Actual Blood Alcohol for PAN and N-PAN Sessions for Subject 5 (Diagonal Line Represents Accurate Estimates.)

represent the sequela of moderate to heavy drinking the night prior to PAN sessions.

Evidence against the existence of PAN II for Subject 5 includes the lack of nystagmus in pre-drink recording periods when the head was turned to the right. Thus, Subject 5 may have been exhibiting a directional nystagmus due to the type of organic deterioration attributed to long histories of alcoholism by Nsamba and Al-Marashi (1972). Secondly, three months following the termination of the investigation, Subject 5 was questioned about the possible role of unauthorized drinking in the data generated during the study. His unequivocal response was that he had engaged in no drinking outside of the experiment.

Nonetheless, the pre-drink PAN II data suggest that Subject 5 may have been continuing to engage in undetected drinking between experimental sessions, a finding that would serve to vitiate data generated by this subject in the present experimental procedure.

The final factor which serves to further undermine the validity of data from Subject 5 is the high degree to which auditory acuity scores in PAN sessions, taken continuously between recording periods, suggest inattention to instructions within the experimental procedure. Figure 3 demonstrates the extent to which Subject 5 did not respond to auditory signals presented between recording periods during PAN sessions. The mean and standard deviation

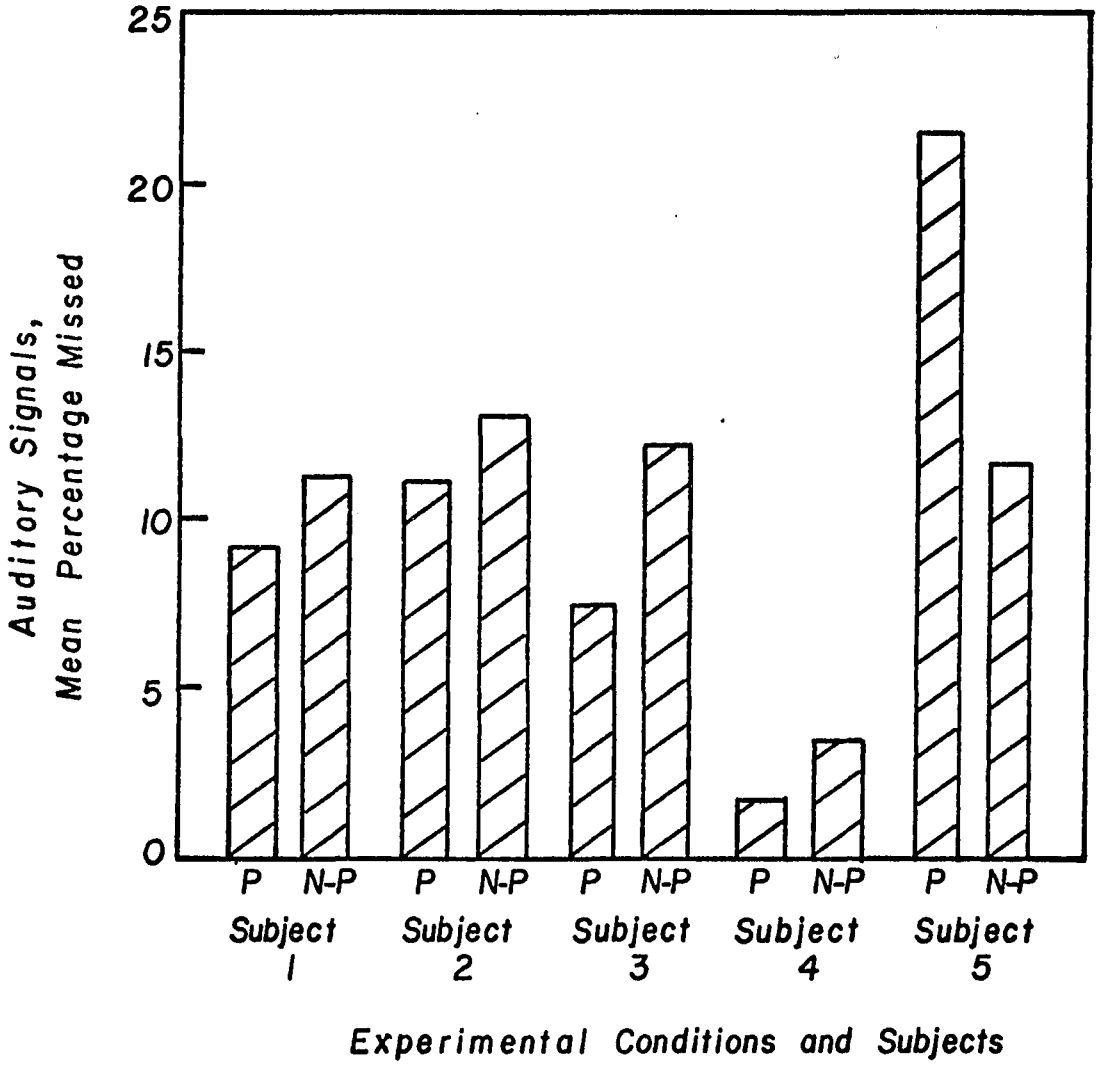

Figure 3. Mean Percentage of Auditory Signals Missed for Each Subject in Each Experimental Condition.

of percentage of signals missed over all experimental sessions for Subject 5 were 16.46% and 8.32%, respectively. The means and standard deviations for the remaining subjects were as follows: Subject 1 = 9.77% and 7.24%; Subject 2 = 12.01% and 7.06%; Subject 3 = 9.31% and 6.97%; Subject 4 = 2.91% and 3.31%. Over all experimental sessions, Subject 5 responded within a range of 0.00% to 29.41% missed auditory signals per session. It is most probable, then, that this subject was not missing signals due to a structural hearing loss. Rather, it is likely that his attention to experimental instructions waxed and waned throughout the procedure.

Because of all these findings in concert, not any one singularly, a second analysis of covariance with Subject 5 excluded was performed on the deviations between estimated and actual blood alcohol data. The sources of variance and results of this analysis are presented in the "Without Subject 5" portion of Table 16, referred to earlier in this section. The analysis suggests that the two treatment variables, body positions in PAN and N-PAN, differed significantly with respect to accuracy of estimation of blood alcohol, with more accurate estimates occurring during the PAN condition. Utility indices performed on sources of variance in the analysis, however, provided an estimate of variance in deviation scores accounted for by treatment conditions of only 4.9%. Thus,

considered as a group design, the present study was minimally effective in demonstrating the superiority of estimation accuracy in PAN over N-PAN sessions.

Despite the low level of confidence ($p < .20$) for the interaction term in the second analysis of covariance, subjects' estimates and deviations were analyzed individually for the following reasons. First, $n = 4$ diminishes considerably the probability of acquiring an F ratio that is significant at the usually acceptable level of confidence ($p < .05$). This consideration, coupled with the finding of a level of confidence value of $p < .20$ (see Table 16) renders interesting the interaction between subjects and treatments when Subject 5 is omitted. Thus, individual as well as further group analyses will be presented for accuracy data.

Accuracy Scores in Training and PAN Sessions

Table 18 presents the nearly perfect inverse correlation ($r = -.92$; $p < .05$; $df = 3$) between accuracy in estimation scores during training and PAN sessions. While Subject 2 estimated most accurately during training, his adjusted mean of deviation scores over PAN sessions was extremely high. Conversely, Subject 1 demonstrated poor accuracy of estimation during training and subsequently exhibited excellent skills at estimation of blood alcohol during PAN sessions. Subjects 3 and 4, both of whom

TABLE 18

Comparison of Mean Deviation Scores Between Estimate and Blood Alcohol in Training and PAN Sessions[a]

Subject	Mean Deviation (mg alcohol/100 ml blood)		Correlation
	Training	PAN	
1	22.47	4.24	-.92 *
2	12.93	26.83	
3	17.00	9.15	
4	18.62	9.77	

[a] PAN scores are adjusted for actual levels of alcohol in the blood

* $p < .05$; $df = 3$

achieved moderate accuracy in training, exhibited medial accuracy of estimation scores during PAN sessions.

Multiple Prediction of Estimation Scores

This section will present, for each subject, results of multiple linear regression analyses in which the independent variables nystagmus, verbal description of nystagmus, and estimate of drink strength were investigated for the contribution of each to variance among each subject's estimates of blood alcohol. These analyses were performed through the use of the computer program BMD-P2R: Stepwise Regression, made available through UCLA's Health Sciences Computing Facility, Los Angeles, California. Briefly, this procedure assigns weights to the independent variables in accordance with the contribution that each makes to the overall variance in estimation of blood alcohol scores. The weight for each variable is then multiplied by the first-order correlation between that variable and estimation of blood alcohol scores in order to arrive at an estimation of total variance contributed by that independent variable.

Subject 1. The covariance between estimates and actual blood alcohol is presented for Subject 1 in Figure 4. Perfect accuracy is represented by any point falling on the 45-degree linear function in Figure 4. Accuracy was found to vary little across both PAN and N-PAN sessions. It can be seen in Table 14 that all but two N-PAN sessions

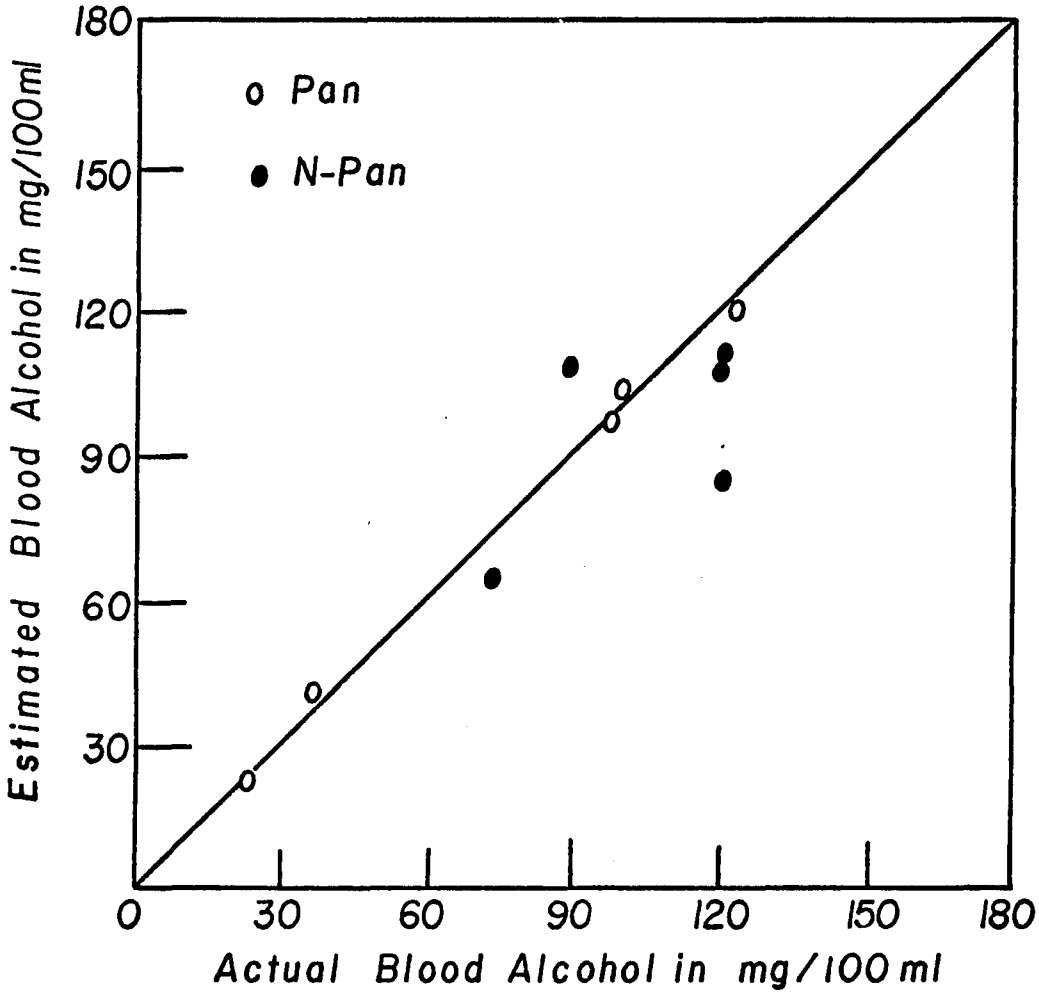

Figure 4. Estimated Blood Alcohol as a Function of Actual Blood Alcohol for PAN and N-PAN Sessions for Subject 1 (Diagonal Line Represents Accurate Estimates.)

conformed to a general 15 mg/100 ml deviation criterion, used by Silverstein et al. (1974). Because accuracy did not vary much across sessions, as reference to Figure 5 will demonstrate, Subject 1 probably was performing at his asymptote for accuracy of estimation of blood alcohol. Reference to Table 14 shows the mean difference between PAN and N-PAN scores. Little overlap between scores in the two conditions occurs despite the generally high level of accuracy in N-PAN. Thus, estimation in PAN appears more accurate than that in N-PAN, despite the high level of accuracy in the latter.

Results from the multiple regression analyses for Subject 1 are presented in Table 19. Estimate of drink strength was found to be significantly correlated ($p < .05$; $df = 3$) with variation in blood alcohol estimation, especially in PAN. Despite a significant ($p < .05$; $df = 4$) first-order correlation between nystagmus and blood alcohol estimation in PAN, little was contributed to the dependent variable by nystagmus because of a similarly high, but not significant ($p < .05$; $df = 3$) correlation between nystagmus and drink estimates ($r = .81$). In N-PAN, the nystagmus variable contributed a sizeable portion to the variance even though little relationship was found to exist between eye movement and blood alcohol in N-PAN ($r = .26$), as reference to Table 8 will bear out. This finding is interesting with respect to the lower accuracy of

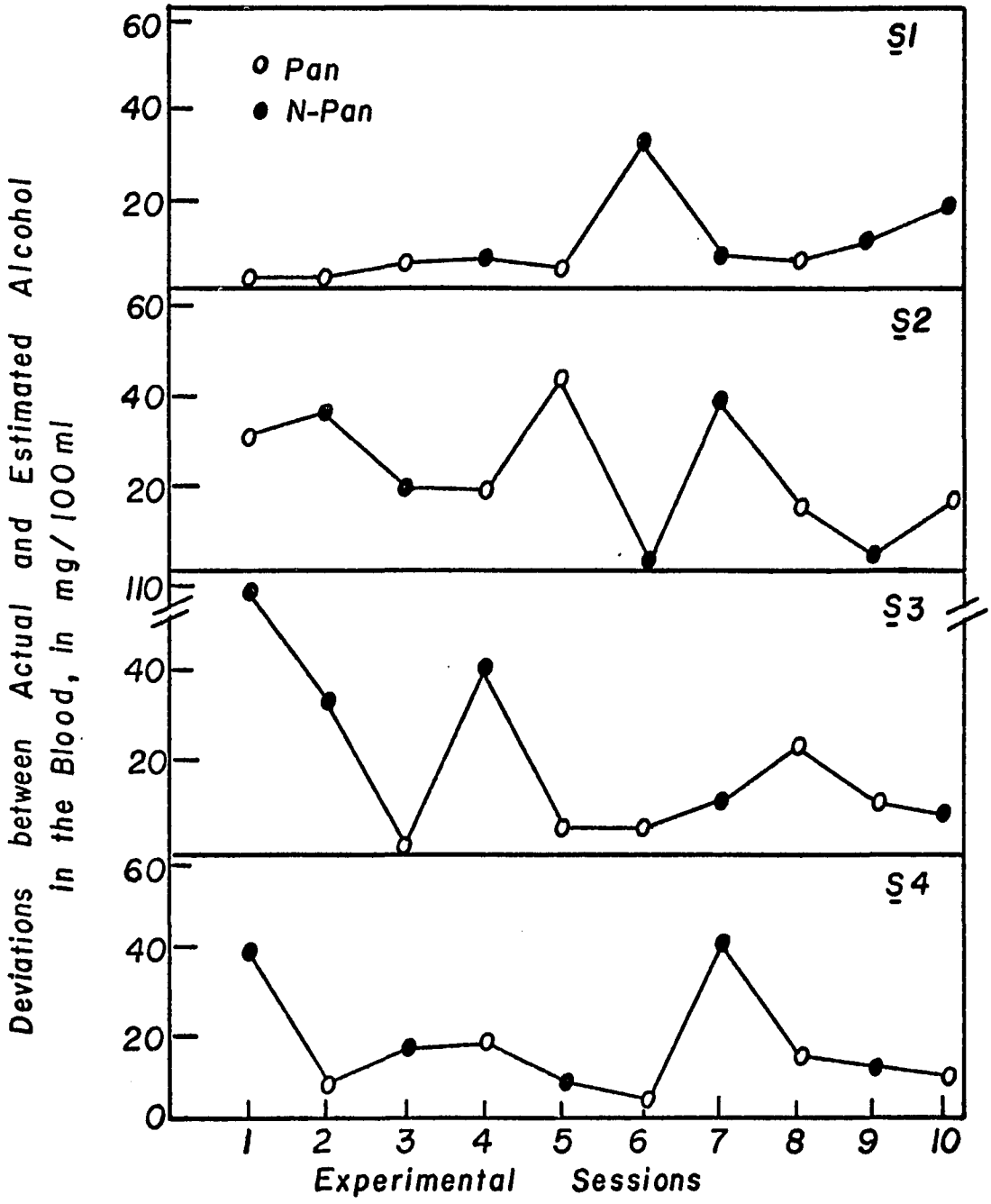

Figure 5. Trend Across Sessions in Deviations Between Estimated and Actual Blood Alcohol for Each Subject

TABLE 19

First-Order Correlations, Beta Weights, and Their Product, Percent Variance in Estimation of Blood Alcohol Contributed by Nystagmus and Drink Strength Variables in PAN and N-PAN for Subject 1

	Nystagmus	Verbal Description of Nystagmus	Estimate of Drink Strength
	PAN Sessions		
Correlation	.89 *	.46	.99 *
Beta Weight	NE	-.205	1.110
% Variance	NE	-9.5	109.5
	N-PAN Sessions		
Correlation	.70 *	-.70	.88 *
Beta Weight	.456	NE	.729
% Variance	31.8	NE	64.2

Note. NE = not entered in regression equation because of insignificant contribution to total variance.

* $p < .05$

estimation in N-PAN than in PAN, where a significant ($p < .05$; $df = 4$) positive relationship existed between nystagmus and blood alcohol ($r = .91$; see Table 3). This observed relationship is tenuous, however, in light of the multiple regression analysis, in which differences between PAN and N-PAN in the degree of contribution made by the drink strength variable are seen to be of primary importance in determining differences in accuracy of estimation between PAN and N-PAN. This finding seems most veracious when dosage level and respective drink strength estimates are compared. Table 20 presents these data for Subject 1. Session 6, a N-PAN session and the most deviant estimate trial, is seen to deviate from the extremely close relationship between dose and drink strength estimates found in the other sessions.

In summary, Subject 1 estimated blood alcohol with high accuracy in both PAN and N-PAN sessions. This degree of accuracy was related primarily to the estimate of drink strength variable in both conditions. The significant relationship between blood alcohol and nystagmus in PAN may have contributed to the degree of accuracy in that experimental condition and, conversely, the low relationship between blood alcohol and eye movement may have suppressed accuracy in N-PAN sessions. Nonetheless, the contribution by the estimate of drink strength variable was the best predictor of accuracy in both experimental conditions, according to the multiple regression analysis.

TABLE 20

Ranking of Doses with Drink Strength Estimates Over Sessions for Subject 1

Session[a]		Dose[b]	Drink Strength Estimate[c]
2	(PAN)	.50	1
3	(PAN)	.75	2
7	(N-PAN)	1.12	1
10	(N-PAN)	1.12	3
8	(PAN)	1.30	4
5	(PAN)	1.44	4
4	(N-PAN)	1.50	5
9	(N-PAN)	1.68	5
6	(N-PAN)	1.78	3

[a] Drink estimate collected for only nine of the ten sessions.

[b] g alcohol/kg body weight

[c] Expressed within scale varying between 1 - 5, with low scores indicating weak tasting drinks.

Subject 2. The covariation between estimates of blood alcohol and actual blood alcohol is depicted for Subject 2 in Figure 6. Reexamination of Table 14 reveals that estimates reached the informal accuracy criterion of 15 mg/100 ml only twice, both times in N-PAN. Other deviations were highly variable, with little apparent difference between PAN and N-PAN sessions. A possible trend, seen in Figure 5, may exist across sessions in the direction of increasingly accurate estimates with practice.

The multiple regression equation for PAN sessions of Subject 2, represented in Table 21, suggests that nystagmus scores and verbal description of nystagmus were correlated equally with the estimation of blood alcohol scores, though the percent contributions to the regression equation by each were relatively low. No significant relationship was found to exist between verbal description of nystagmus and actual nystagmus scores ($r = -.16$).

Multiple regression analysis for N-PAN sessions, presented in Table 21, indicated that estimation of drink strength was the primary predictor of estimation of blood alcohol. As previously presented in Table 13, Subject 2 was highly accurate in ranking drink strength ($r = .90$). Nystagmus scores were found to suppress the magnitude of the relationship between the other two variables and the estimates. This effect was due to the existence of some factor shared by the three independent variables that was

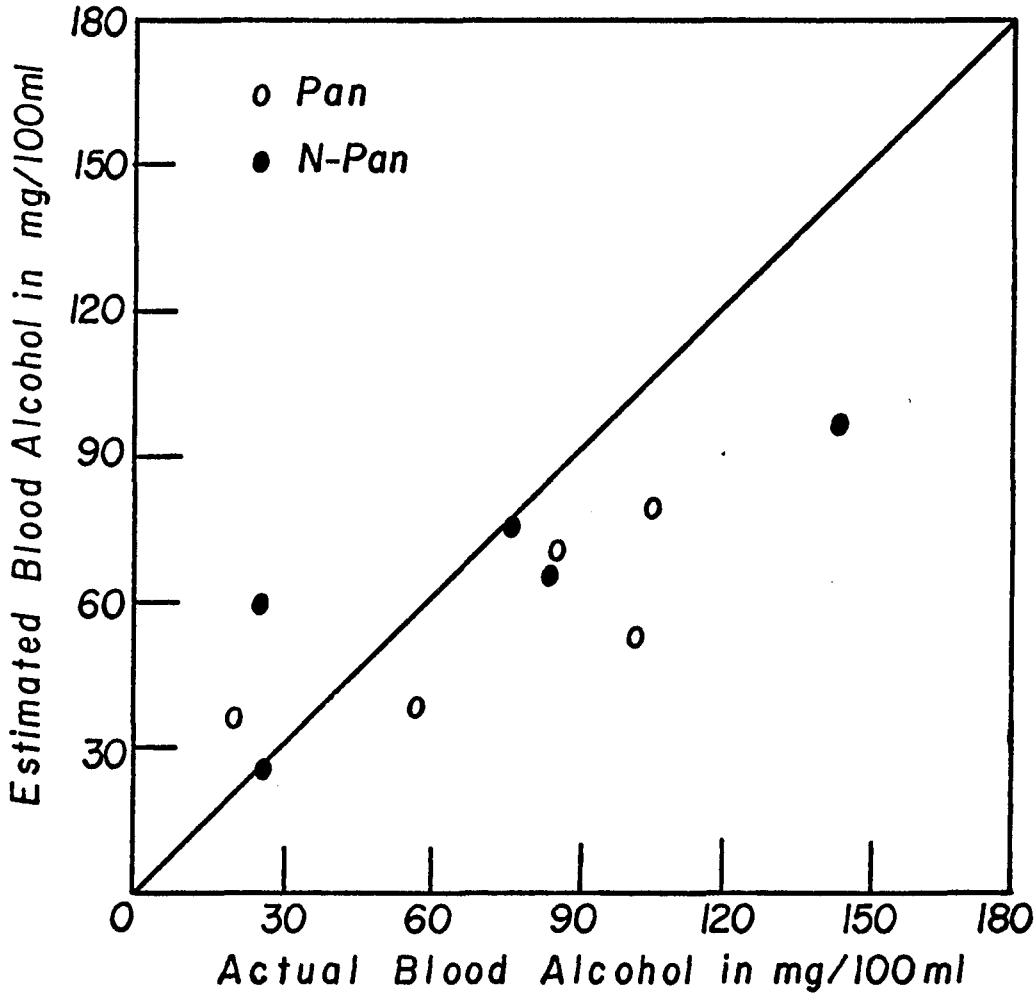

Figure 6. Estimated Blood Alcohol as a Function of Actual Blood Alcohol for PAN and N-PAN Sessions for Subject 2 (Diagonal Line Represents Accurate Estimates.)

TABLE 21

First-Order Correlations, Beta Weights, and Their Product, Percent Variance in Estimation of Blood Alcohol Contributed by Nystagmus and Drink Strength Variables in PAN and N-PAN for Subject 2

	Nystagmus	Verbal Description of Nystagmus	Estimate of Drink Strength
		PAN Sessions	
Correlation	.54	.55	-.05
Beta Weight	.651	.657	NE
% Variance	35.3	33.1	NE
		N-PAN Sessions	
Correlation	-.68	.31	.80
Beta Weight	.423	.715	1.256
% Variance	-28.7	22.3	99.9

Note. NE = not entered in regression equation because of insignificant contribution to total variance.

irrelevant to variation in the dependent variable. The nystagmus variable, then, served to suppress the irrelevant factor in the regression equation.

The individual analysis of accuracy of estimation for Subject 2 indicates that the best correlates of estimates of blood alcohol in PAN sessions were actual nystagmus and verbal description of nystagmus. These two predictors were not related to one another as would be expected and, furthermore, a significant percentage of the variation (31.6%) in estimates remained unexplained. In N-PAN, estimates of drink strength were related most significantly to estimates of blood alcohol. Nonetheless, accuracy remained poor, though somewhat improved over that in PAN.

Subject 3. Although correspondence between estimates and blood alcohol in PAN was consistently high, correspondence in N-PAN was generally low, as can be observed in Figure 7. Inspection of Figure 5 suggests that an apparent trend toward lower deviations over sessions can be accounted for by the juxtaposition of inaccurate estimations during N-PAN sessions and accurate estimations during PAN, with three of the first four sessions being N-PAN. Therefore, it is likely that this subject was performing at asymptote.

Table 22 presents results from the multiple regression analysis for Subject 3. The nystagmus variable accounted for the majority of the variation in estimates of blood alcohol in both PAN and N-PAN sessions. The

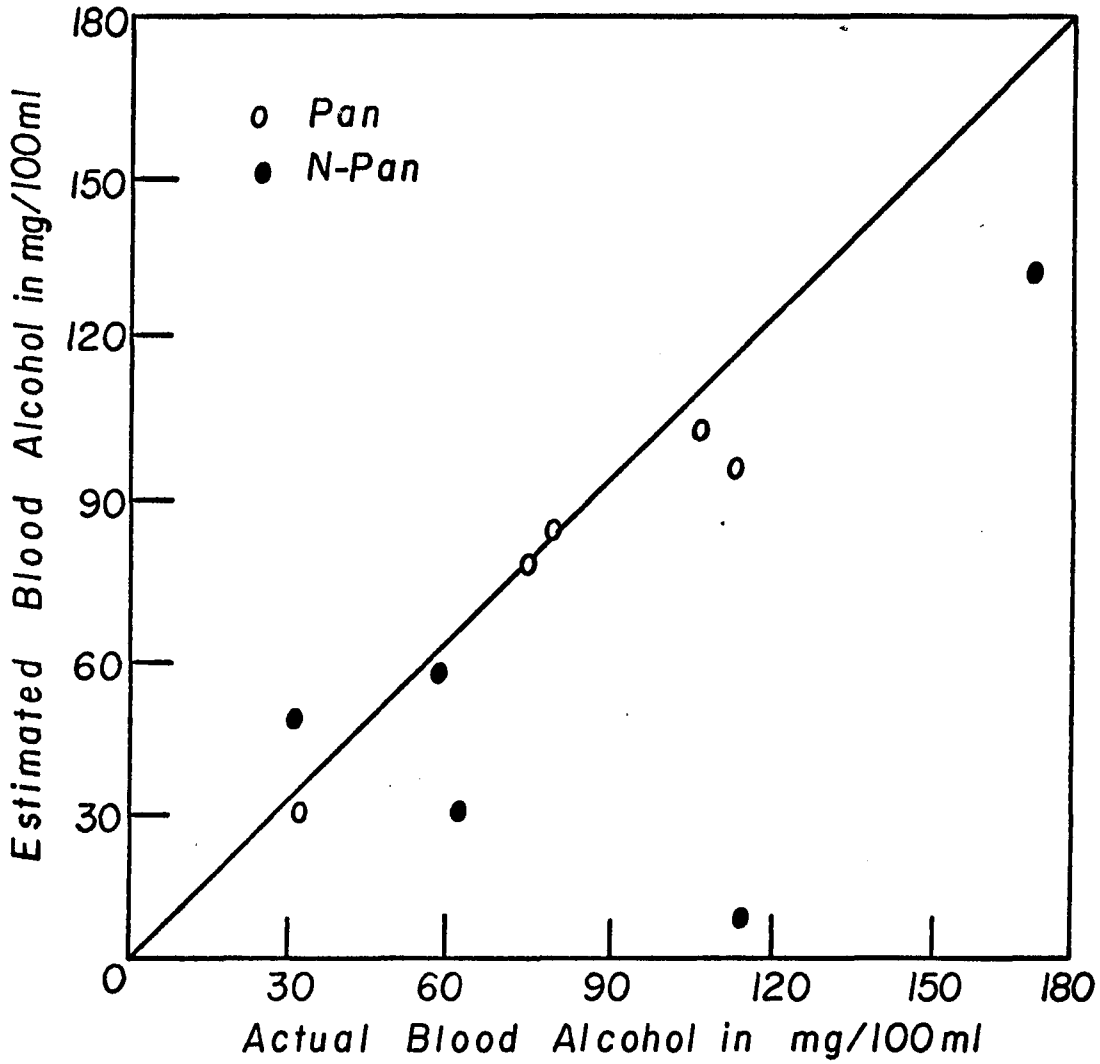

Figure 7. Estimated Blood Alcohol as a Function of Actual Blood Alcohol for PAN and N-PAN Sessions for Subject 3 (Diagonal Line Represents Accurate Estimates.)

TABLE 22

First-Order Correlations, Beta Weights, and Their Product, Percent Variance in Estimation of Blood Alcohol Contributed by Nystagmus and Drink Strength Variables in PAN and N-PAN for Subject 3

	Nystagmus	Verbal Description of Nystagmus	Estimate of Drink Strength
		PAN Sessions	
Correlation	.84 *	.74	.46
Beta Weight	.812	NE	.410
% Variance	67.8	NE	18.7
		N-PAN Sessions	
Correlation	-.55	-.26	.62
Beta Weight	-.748	-.552	.279
% Variance	41.2	14.3	17.2

Note. NE = not entered in regression equation because of insignificant contribution to total variance.

* $p < .05$

proportion of variance accounted for by nystagmus in PAN is particularly noteworthy. Verbal description of nystagmus and estimates of drink strength contributed little to the overall account of estimates of blood alcohol. A significant ($p < .05$; $df = 4$) positive relationship exists between verbal description of nystagmus and estimation of blood alcohol despite the absence of a significant contribution to the regression equation by the former. This absence is due to an even stronger relationship between nystagmus and verbal description of nystagmus, a finding that will be further explicated in another section.

In summary, estimates of blood alcohol were found to vary primarily as a function of the nystagmus variable in both PAN and N-PAN conditions for Subject 3.

Subject 4. For Subject 4, covariation between actual and estimated blood alcohol, seen in Figure 8, was lower in N-PAN than in PAN. Estimation accuracy in PAN fell within the informal criterion of 15 mg/100 ml in four of five sessions, as has been seen in Table 14. No noticeable trend in accuracy over sessions can be observed in Figure 5.

Nystagmus accounted for a high proportion of variance in estimates of blood alcohol in PAN sessions, as can be seen in Table 23. No other variable in either PAN or N-PAN contributed significantly to estimation variance. The first-order correlation between verbal description of nystagmus and estimation of blood alcohol was high, though

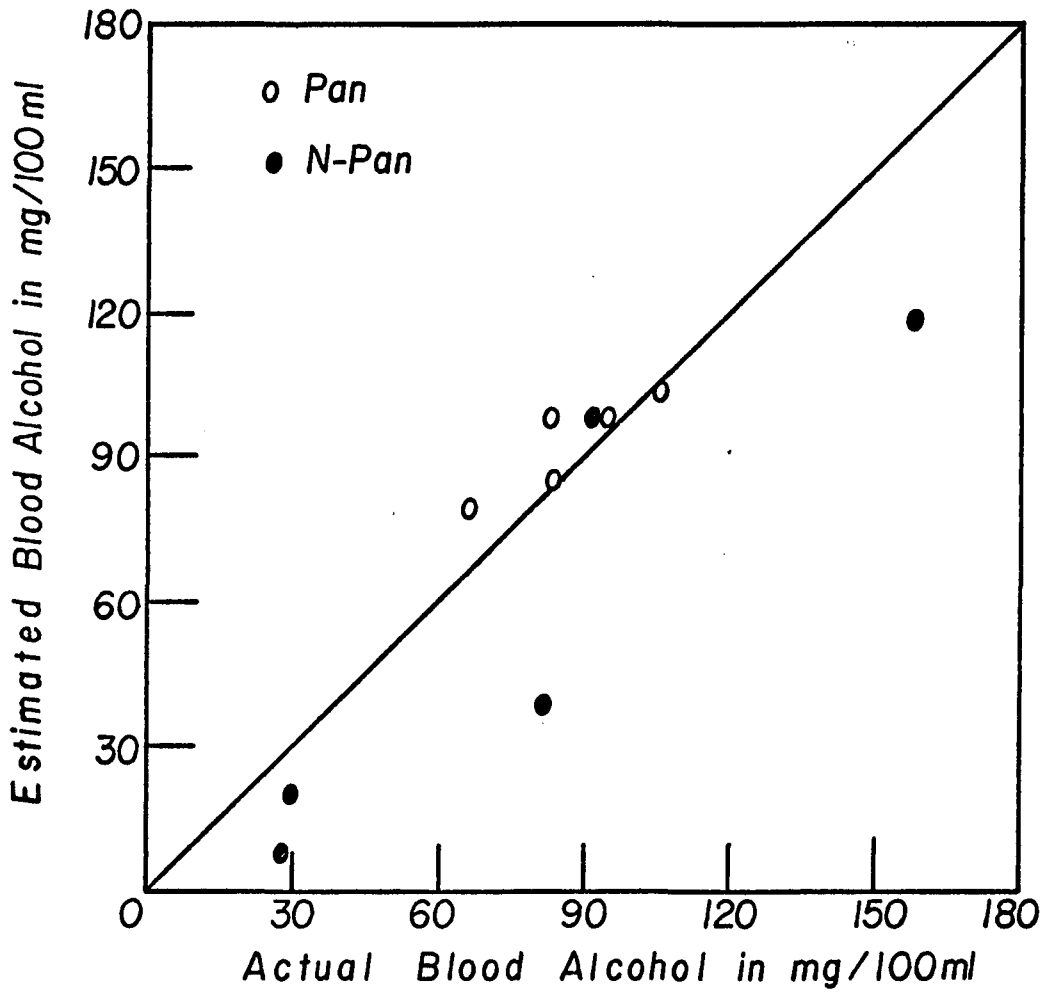

Figure 8. Estimated Blood Alcohol as a Function of Actual Blood Alcohol for PAN and N-PAN Sessions for Subject 4 (Diagonal Line Represents Accurate Estimates.)

TABLE 23

First-Order Correlations, Beta Weights, and Their Product, Percent Variance in Estimation of Blood Alcohol Contributed by Nystagmus and Drink Strength Variables in PAN and N-PAN for Subject 4

	Nystagmus	Verbal Description of Nystagmus	Estimate of Drink Strength
		PAN Sessions	
Correlation	.71	-.65	.31
Beta Weight	.852	NE	.536
% Variance	60.7	NE	16.8
		N-PAN Sessions	
Correlation	.12	.10	-.26
Beta Weight	NE	NE	NE
% Variance	NE	NE	NE

Note. NE = not entered in regression equation because of insignificant contribution to total variance.

nonsignificant at the .05 level, yet the variable did not enter in the regression equation. This effect was due to a significant ($p < .05$; $df = 4$) relationship between actual nystagmus and verbal description of nystagmus ($r = -.92$), a finding which served to reduce the importance of the latter in predicting estimates of blood alcohol.

Thus, the relatively accurate estimates of Subject 4 in PAN were predicted by actual nystagmus, while none of the independent variables observed were instrumental in explaining the less accurate estimates in N-PAN sessions.

Relationship Between Actual Nystagmus and Verbal Description of Nystagmus

Table 24 presents correlations for comparisons between scores for actual and verbal description of nystagmus. The magnitudes of these correlations should explain the degree to which subjects were aware of measureable changes between pre- and post-drink levels of eye movement or nystagmus. Subject 1, for whom estimation of blood alcohol was primarily associated with drink strength, demonstrated no verbal awareness of nystagmus change in either PAN or N-PAN sessions according to correlations presented in Table 24. Similarly, Subject 2 exhibited little relationship between actual nystagmus and verbal description of nystagmus. For that subject, drink strength was seen to explain the majority of the variation in

TABLE 24

Pearson Product-Moment Coefficients of Correlation Describing Relationships Between Actual Nystagmus Scores and Verbal Description of Nystagmus Scores

	Experimental Condition	
Subject	PAN	N-PAN
1	.05	-.23
2	-.16	-.29
3	.85 *	-.49
4	-.92 *	-.69

* $p < .05$; $df = 4$

estimates of blood alcohol in N-PAN, whereas relatively insignificant covariation between independent variables and estimation of blood alcohol was observed in PAN sessions. On the other hand, Subjects 3 and 4, both of whom generated high accuracy of estimation in PAN, exhibited significant ($p < .05$; $df = 4$) correlations between actual nystagmus and verbal description of nystagmus in PAN. While Subject 3 displayed a significant ($p < .05$; $df = 4$) high positive correlation, suggesting verbal awareness of nystagmus, Subject 4 exhibited a significant ($p < .05$; $df = 4$) negative correlation. Hence, for Subject 4, increases in eye movements resulting from alcohol ingestion were reported as decreases in activity in the eyes. Nonetheless, inspection of Table 24 along with review of Tables 19, 21, 22, and 23 suggests that the degree to which nystagmus in PAN was correlated with estimates of blood alcohol may have been related to the strengths of association between subjects' verbal behavior and nystagmic events in pre- and post-drink recording sessions.

Weber's Law: The Relationship Between Accuracy and Levels of Alcohol in the Blood

The coefficients of correlation between deviation scores and absolute levels of blood alcohol for Subjects 1 - 4 were +.20 in PAN and +.37 in N-PAN. Scatter plots showing the distributions of deviation or error scores over

levels of blood alcohol for all subjects in each of the two experimental conditions are presented in Figure 9. These data portray no significant relationship between accuracy and absolute blood alcohol.

An alternative approach to the relationship between accuracy and blood alcohol is of interest. Conceptualized within the framework of a psychophysical demonstration, this study has employed a procedure akin to the "Method of Average Error" (Woodworth and Schlosberg, 1954). Also referred to as the Equation or Adjustment Method, this procedure requires that the subject adjust a stimulus until it appears equal to a standard stimulus presented by the experimenter. The difference between the adjusted setting and the standard constitutes the error. Several error scores are averaged and the standard deviation is calculated. This standard deviation serves perfectly as a measure of discrimination or as a test of Weber's Law (Woodworth and Schlosberg, 1954).

In the present study, the actual level of blood alcohol represents the standard and the estimated blood alcohol is roughly analogous to the adjusted stimulus. The major deviation between the procedure in this study and that described for traditional methods by Woodworth and Schlosberg (1954) is the use, in this study, of a varying standard. The traditional method typically uses a constant standard, but may use several different standards.

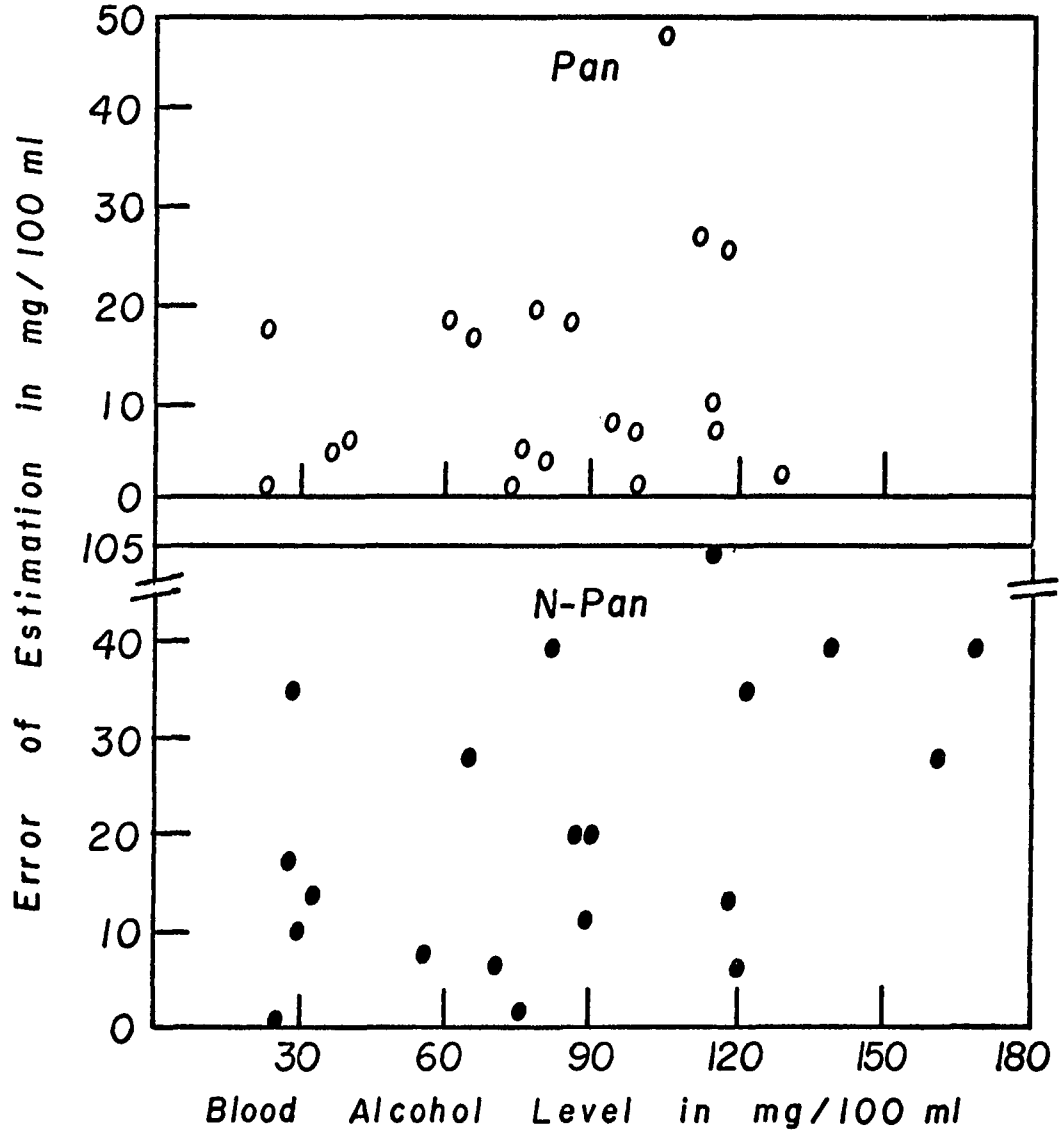

Figure 9. Scatter Plots Depicting Lack of Significant Relationships Between Error of Estimates (Deviation Scores) and Levels of Alcohol in the Blood in PAN and N-PAN Sessions

A comparison of Weber's constants for several senses, computed by Boring, Langfeld, and Weld in 1948 (Woodworth and Schlosberg, 1954), with the ratio of the standard deviations for estimates in each experimental condition over the mean level of blood alcohol in each condition is of interest. The latter mean ratios of .13 in PAN and .26 in N-PAN were found to vary around Weber's constants for smell (.104), cutaneous pressure (.136), and taste (.200). These values obtain in the mid-ranges for intensity within each of the sensory modalities.

Although only roughly analogous, these comparisons suggest that blood alcohol in PAN represents a stimulus dimension with a smaller difference limen (DL) or threshold than blood alcohol in N-PAN. Secondly, the similarity between the DL for taste and that for blood alcohol in N-PAN is consistent with the findings for two subjects, presented in Tables 19 and 21, that estimation of drink concentration served to explain large amounts of variance in N-PAN trials. This similarity between stimulus thresholds for taste and blood alcohol in N-PAN sessions strengthens the finding that, for two subjects in this study, alcohol taste stimuli and estimations of blood alcohol were highly correlated in N-PAN sessions. Another explanation for the estimation of drink strength, however, is that burning or pain, and not taste was the effective stimulus. If veridical, the present comparison between difference limens for taste and blood alcohol could be misleading.

Attention to Auditory Signals

The mean percent of signals missed in PAN and N-PAN sessions has been presented in Figure 3, referred to previously. These data were subjected to a 2 x 4 analysis of variance, using experimental conditions (2) and subjects (4) as factors. While the experimental conditions and the subjects x experimental conditions sources were not significant, a significant *F* ratio was found for subjects, as can be seen in Table 25. Thus, even without the variant data of Subject 5, subjects differed significantly with experimental conditions pooled. A Newman-Keuls post-hoc test, presented in Table 26, identified Subject 4 as missing significantly fewer signals than Subjects 1, 2, and 3. Most important to this investigation is the finding that attention to auditory signals did not vary significantly between experimental conditions. This finding suggests that subjects' attention to verbal instructions did not differ significantly between PAN and N-PAN experimental sessions.

TABLE 25

Analysis of Variance on Attention to Auditory Signals for Subjects 1 Through 4

	ANOVA		
Source	df	MS	F
Subjects (S)	3	152.76	3.19*
Experimental Conditions (T)	1	77.69	1.62
S x T	3	4.16	.09
Error	32	47.82	

*$p < .05$.

TABLE 26

Newman-Keuls Post-Hoc Analysis on Attention to Auditory Signals

Order	1	2	3	4
	Subject 4 29.12	Subject 2 93.12	Subject 1 97.75	Subject 3 120.10

	Differences			
Subjects	4	2	1	3
4		64.04*	68.63*	90.98*
2			4.59	26.94
1				22.35
3				

	Steps Between Totals		
Critical Values	2	3	4
$q_{.95}(3,32)$	2.88	3.48	3.83
$q_{.95}(3,32)\left(\sqrt{nMS_{error}}\right)$	44.53	53.81	59.22

*$p < .05$.

CHAPTER IV

DISCUSSION

The purpose of the present investigation has been to explicate parameters responsible for the accurate estimation of alcohol in the blood by human subjects with histories of heavy drinking. The parameter chosen for close examination was the body position required to generate positional alcohol nystagmus I, (PAN I), an ocular response demonstrating a linear relationship with increasing levels of alcohol in the blood (Aschan et al., 1956; Goldberg, 1970). The role of previous feedback for levels of blood alcohol in a single drinking session was minimized by programming only one estimate of blood alcohol per session. Similarly, an unsuccessful effort was made to disguise the concentration of alcohol in the orally administered drink in order to minimize the role of each subject's evaluation of drink strength in making a subsequent estimation of blood alcohol. Attempts to control for the influence of these variables were performed because of apparent confounding by them in previous attempts at teaching heavy drinkers to discriminate blood alcohol (Lovibond and Caddy, 1970; Silverstein et al., 1974; Vogler, et al., 1975).

The experimental design chosen for the present study was a discrete trial paradigm in which subjects, already estimating near asymptote, estimated blood alcohol under two conditions, one involving the presence and the other the absence of opportunity to experience PAN I. Support for the hypothesis under investigation was expected to be observed via differences in accuracy in estimation under the two PAN conditions, given that an empirical relationship between nystagmus and actual levels of alcohol in the blood was obtained.

Before discussing this major hypothesis, however, an important and unexpected finding that resulted from the administration of doses of alcohol to subjects will be discussed, i.e., the non-equivalence of measured levels of alcohol in the blood across subjects, following essentially equivalent doses of alcohol.

Dosage and Measured Levels of Blood Alcohol

The empirical ratios of blood alcohol to dosage, calculated over sessions for each subject, varied between 58.66 and 72.35 mg/100 ml/unit dosage. This finding suggests that subjects may have exhibited differences in rates of absorption, elimination, or both. Wallgren and Barry (1970, pp 518 - 522) have reviewed research with alcoholic humans in which rates of elimination of alcohol have been seen to increase systematically with duration of heavy

drinking history. A comparison of Table 1 with Table 2, previously presented, bears out the positive relationship between number of previous hospitalizations and measured blood alcohol. Number of prior hospitalizations represents a more reliable indicator of severity of drinking problem than other verbal measures because it requires verbal report of relatively discrete and discernable events. Furthermore, it is easily verified. Verbal report of duration of drinking problem is too ambiguous to be considered valid.

Because time since the last meal and the interval between dosage and measurement were controlled, it is clear that subjects in this study differed with respect to empirical dose-blood alcohol ratios; furthermore, these differences between subjects were correlated with differences in drinking history. This finding will assume, in a later section, an important role in the discussion of accuracy of estimation of blood alcohol.

The relationship between the empirical ratios of dosage to blood alcohol, in this study and in that of Aschan et al. (1956), is of interest at this point. Aschan et al. (1956) used "non-alcoholic" subjects and presented data from which a mean ratio of 98.38 mg/100 ml to each 1.0 g/kg was obtained. That figure is roughly equivalent to the ratios (see Table 2) calculated for the three subjects in this study with the least severe drinking histories, if approximately 30 mg/100 ml is added to their scores in order

to adjust for the difference between blood alcohol measures from breath and blood samples. Subjects 2 and 5, who demonstrated the lowest levels of blood alcohol per unit dose, exhibited the most severe histories of heavy drinking. This finding, along with the higher figures for blood alcohol in Subjects 1, 3, and 4, suggests that individuals with severe histories of problem drinking may exhibit absorption-elimination values different from those for individuals with less severe histories, as has been suggested in the review by Wallgren and Barry (1970). Hence, these data may shed light on 'tolerance' to alcohol phenomena reported frequently in the literature. These findings also warrant the examination of the relationship between severity of drinking and nystagmus scores. 'Tolerance' as an inferential notion could be further supported through findings of either (1) greater absolute nystagmus values, given equivalent dosages, or (2) higher relationships between nystagmus and blood alcohol, in PAN sessions for subjects with relatively non-severe histories of drinking compared to those with severe histories.

Positional Alcohol Nystagmus and Blood Alcohol

The findings of four of five significant positive correlations between blood alcohol and nystagmus in PAN, along with no consistent relationship across subjects in N-PAN, satisfy the basic tenet upon which this research is

predicated; that is, predictable ocular responses to blood alcohol were present in PAN sessions, but not present in N-PAN sessions. Placing each subject in a supine position with his head turned either to the right or left resulted in a regular nystagmus, in the direction of the head turn, that was dependent upon the level of alcohol in the blood. Conversely, placing each subject in a sitting position with his head fixed in a forward direction produced no regular ocular events related to blood alcohol. The finding of a positional alcohol nystagmus in PAN sessions is consistent with several reports summarized by Naitoh (1972). The negative finding with regard to ocular movement in N-PAN sessions is consistent with the lack of published reports describing measureable ocular events generated by alcohol when subjects are sitting with heads forward and eyes open, without movement in the visual field.

Coefficients of correlation for agreement between scorers of actual rate of change of nystagmus from pre-drink to post-drink in PAN sessions were consistently above +.80, while those for ocular movement in N-PAN sessions were more variable. A tenable hypothesis for the explanation of this difference is that positional alcohol nystagmus is predictable and objectively observable, having a regular frequency of occurrence and magnitude. Hence, scoring reliability was high for PAN sessions. On the other hand, no ubiquitous ocular phenomenon, measured in this

study, was correlated with the body position assumed during N-PAN; therefore, the ocular events occurring during recording periods in N-PAN were unpredictable and irregular in frequency and magnitude, making scoring more difficult and tenuous.

An alternative hypothesis for the explanation of higher reliability of scoring of nystagmus in PAN than in N-PAN stems from the possibility that scorers were more rigorous in scoring PAN than N-PAN sessions, thereby producing scores more representative of ocular event in PAN than N-PAN. Despite the scorers' blindness to the hypothesis under investigation, the dissimilarity between PAN and N-PAN records, i.e. four 30-second recordings in PAN and two 60-second recordings in N-PAN, may have rendered scoring error a possible source of variance in differences between PAN and N-PAN scoring reliabilities.

Another issue concerning the occurrence of nystagmus in PAN sessions will be considered here but discussed with respect to its implications later. Both the absolute magnitude of nystagmus and the strength of association between blood alcohol and nystagmus within subjects were positively related to the number of previous hospitalizations for heavy drinking. Comparison of Table 1 with Tables 3 - 7 bears out this relationship. As was the case with dosage and subsequent levels of alcohol in the blood, it appears that subjects vary with regard to the extent to

which blood alcohol generates nystagmus in PAN sessions. Furthermore, two of three subjects with the least severe histories of drinking experienced nystagmic eye movements that were more highly dependent upon the level of alcohol in the blood than for subjects with more severe drinking histories. These findings augment the finding of lower blood alcohol per unit dose in subjects with more severe histories of heavy drinking. The possibility that these findings are related to 'habituation' and 'tolerance' phenomena cannot be discounted. There are too few subjects in this investigation, however, to make any stronger statements about these observations.

Accuracy in Estimation of Blood Alcohol

A major finding of this study was the significantly different accuracies in estimation across subjects, following the removal of Subject 5, between PAN and N-PAN experimental conditions.

The reasons for removal of Subject 5 have been explained, i.e., lack of variability in estimation scores, liklihood of unauthorized drinking within 24 hours of experimental sessions, and poor attention to auditory signals. The circumstances under which Subject 5 was accepted into the study are also of interest at this point. Subject 5 had been living at the hospital at which the research was carried out for more than six months, presumably

because of a lack of personal resources outside the hospital. He had been receiving considerable pressure to make living arrangements outside the hospital. It is probable that his primary motivation to participate in the study was his need for continued housing through the projected one month duration of the experiment. This condition of deprivation was inadequate in insuring acquisition of accurate estimation of blood alcohol because accurate estimation was not a necessary condition for completion of the effective contingency hypothesized for Subject 5. A theoretical discussion of reinforcement for accurate estimation of blood alcohol must include the therapeutic benefit for acquiring that skill. The present study was designed on that theoretical tenet; that is, subjects were chosen for their motivation to change dangerous drinking habits. It is suggested herein that reinforcement was not available for accurate estimations because of insufficient deprivation conditions for Subject 5.

Although the predicted difference between accuracy of estimation between PAN and N-PAN was obtained, as mentioned above, the utility index for this difference was only 4.9%. This low utility index for the independent variable, body and head position, may have been due to physiological changes, other than nystagmus, contributing to the estimation of blood alcohol. Another reason for this low utility index was the often accurate estimation of blood

alcohol in N-PAN sessions by all subjects. This accuracy may have been related to variables other than the independent variable, i.e., body position. The primary variable responsible for occassionally accurate estimates in N-PAN, according to the multiple regression analyses, was the estimation of drink strength.

Another reason for the low index of utility is obvious through inspection of Table 14, previously presented, which reveals large differences between the adjusted means of Subjects 1, 3, and 4, on one hand, and Subject 2, on the other. Unlike the others, Subject 2 did not come under the control of PAN in estimating blood alcohol, as is suggested by the large errors in estimation for this subject in both PAN and N-PAN sessions.

A variable that may have been strongly related to the large PAN deviations for Subject 3 was the acquisition of high accuracy of estimation of blood alcohol during training sessions. Subject 2 was the only experimental participant who, in training sessions, demonstrated a mean accuracy score under the informal criterion of 15 mg of alcohol per 100 ml of blood, specified by Silverstein et al. (1974). Because several estimation trials were included in each daily session in training sessions, multiple Breathalyzer feedback was available. A criticism of previous demonstrations of discrimination of blood alcohol, made herein, was the existence of opportunity for previous

feedback in a drinking session to influence subsequent estimates within the same session. It is conceivable that Subject 2 in this study came under the control of previous feedback while failing to learn to use positional alcohol nystagmus in training sessions. The existence of a high negative correlation (r = -.92) between accuracy in training sessions and accuracy in PAN experimental sessions for all subjects further supports the credibility of this hypothesis. If accurate, this hypothesis, i.e., that availability of multiple Breathalyzer feedback within sessions interferes with subsequent accuracy of estimation when antecedent Breathalyzer feedback is absent, suggests that the training of alcoholic subjects in discrimination of varying levels of blood alcohol should be designed so as to eliminate the effect of trial to trial influence of feedback for blood alcohol within a session. Furthermore, this hypothesis may explain the data of Silverstein et al. (1974) suggesting that estimation of blood alcohol does not persist beyond the withdrawal of Breathalyzer feedback, in that Silverstein et al. (1974) used a multiple feedback design.

Accuracy of estimation by Subjects 1, 3, and 4 can be explained most convincingly by appealling to the following two variables: 1) accuracy of estimation of drink strength and 2) use of nystagmus in PAN sessions to make estimates of blood alcohol. Drink strength estimation

was highly accurate (r = .99) in PAN sessions for Subject 1. Furthermore, the multiple regression analysis for Subject 1 assigned an extremely heavy weight to the drink strength variable in predicting estimates of blood alcohol. These considerations, in conjunction with the highly accurate estimates in PAN and slightly less accurate estimates in N-PAN, suggest that Subject 1 may have learned to estimate accurately various levels of alcohol in the blood by using the taste of each alcoholic beverage. The difference between accuracy of estimates in PAN and N-PAN sessions for Subject 1 may have been due to the less accurate estimation of drink strength in N-PAN or, equally probable, to the independent variable, body position, in PAN and N-PAN sessions.

From a theoretical point of view, accurate assessment of drink strength in Subject 1 may have been related functionally to the successful use of drink concentration in making estimates of blood alcohol. It is interesting, at this point, to speculate about the similarly accurate assessment of drink strength (r = .90) by Subject 2 in N-PAN sessions and the percentage of variance in estimation of blood alcohol accounted for by drink strength estimates (99.97). It is likely that following training, Subject 2 was not at asymptote in accurately estimating blood alcohol through the use of nystagmus and drink strength variables because of his having learned to

make accurate estimates by using previous feedback, as discussed in the preceding section. Therefore, the trend across sessions, noted in Figure 6 may represent this subject's acquisition of skill at accurate estimation of blood alcohol through the use of drink strength.

Estimates of blood alcohol for Subjects 3 and 4 were highly accurate in PAN and somewhat less accurate in N-PAN sessions. Multiple regression analyses for both subjects identified actual levels of nystagmus as the most important predictor of estimates of blood alcohol. That both subjects presumably had learned the use of nystagmus in estimating blood alcohol in training sessions is suggested by their stable accuracies of estimation across PAN sessions subsequent to training. In N-PAN sessions, change in eye movements continued to predict estimates, according to the multiple regression equation for that case. The lower accuracy in N-PAN may have been due to the poor relationship between eye movement and blood alcohol (r = .06) for that subject in those sessions. Hence, two of three subjects in this study more accurately estimated blood alcohol in PAN than in N-PAN, and, furthermore, exhibited a high correspondence between estimates of blood alcohol and levels of actual nystagmus. These findings support the hypothesis that positional alcohol nystagmus, as well as other events occurring in PAN but not in N-PAN, can augment the accuracy of discrimination of blood alcohol.

One further observation of interest concerns the strong relationship in PAN sessions between verbal description of nystagmus and actual nystagmus for Subjects 3 and 4, both of whom exhibited much greater accuracy in PAN than in N-PAN sessions. This in concert with findings of heavy weighting for the actual nystagmus variable in the regression equations for both subjects suggests that levels of nystagmus produced by alcohol doses in Subjects 3 and 4 were functionally related to estimates of blood alcohol and, furthermore, that subjects were verbally aware of changes in these nystagmus levels. Curious, however, is the finding that nystagmus was weighted heavily for Subject 4 but was inversely related to verbal description of nystagmus. Thus, when levels of nystagmus were high Subject 4 described low levels verbally. It is difficult to believe that this subject was responding to a cue other than nystagmus because of the findings of the multiple regression analysis, i.e., nystagmus predicted 60.7% of the variance in estimation, and because of the superior accuracy of estimation in PAN sessions when compared to N-PAN sessions. Subject 4, accordingly, was probably mistranslating verbally the ocular events resulting from varying levels of alcohol in the blood. An alternative explanation, however, is that Subject 4 <u>was</u> responding to events correlated with the occurrence of PAN, but uncorrelated with

verbal description of nystagmus and drink strength estimates. This would explain the high account of variance by the nystagmus variable and the inverse relation with verbal report of nystagmus.

The limited correspondence (r = .56) between scorers' assessments of verbal description of nystagmus for Subject 4 in PAN, however, limits the significance of the finding of an inverse relationship between verbal description and actual nystagmus. Furthermore, the generally low coefficients of correlation (range = -.29 to .71) between the two scorers' assessments of PAN sessions for each subject minimizes the meaningfulness of any differences concerning the verbal description of nystagmus variable.

What is and what is not a significant coefficient of correlation, according to Guilford (1965), depends upon the nature of the data under comparison. It is doubtful that any of the scorer reliabilities for verbal description of nystagmus in PAN represents a sufficiently large correspondence to be meaningful when the data being scored are documented and continuously available for scoring. Undoubtedly, higher reliabilities of scoring for verbal description of nystagmus could have been obtained through more extensive and explicit instructions to scorers concerning criteria. It is felt, however, that the reliabilities derived from the present instructions and scoring

procedure represent the level of difficulty involved in agreeing upon verbal descriptions of private events, i.e., feelings.

Evidence pointing to the uselessness of the verbal description of nystagmus variable in predicting accuracy of estimation of blood alcohol is available in Tables 19, 21, 22, and 23, wherein the highest percentage of variance in estimates of blood alcohol accounted for by verbal description of nystagmus was 36.1% in PAN sessions. Further reference to these tables indicates that the verbal description of nystagmus variable failed to enter into the regression equation for two of the four subjects, while serving as a suppressor variable for another.

In conclusion, whether or not verbal awareness of nystagmus is a necessary or sufficient condition for the acquisition of accuracy in estimation of blood alcohol using positional alcohol nystagmus is not clear as a result of this study. Although the subject (Subject 3) who demonstrated the greatest verbal awareness of nystagmus also produced the largest mean difference between PAN and N-PAN estimation scores, the general lack of reliability of scoring for verbal description of nystagmus obfuscates the significance of that finding. Apparently, the methodological difficulties that have plagued research in awareness in conditioning (Greenspoon and Brownstein, 1967) are no less operative here.

A further comment concerning the prediction of accuracy of estimation of blood alcohol comes in the form of a caveat. In the multiple regression analyses performed in this study, an indirect correlation between accuracy of estimation and the nystagmus variable may have reduced the significance of the findings, i.e., major portions of variance in estimation of blood alcohol in PAN for Subjects 3 and 4 were accounted for by the nystagmus variable. Specifically, the degree to which the nystagmus variable predicted estimates was used to explain the overall accuracy of those estimates. Because accuracy is dependent upon the relationship between actual blood alcohol and the estimate, and because nystagmus is highly correlated with actual blood alcohol in PAN sessions, it is possible that this indirect relationship between nystagmus and the estimate variable contributed to the explanation of estimation of blood alcohol by the nystagmus variable.

In defense of the importance of actual nystagmus in accurate estimation of blood alcohol, however, are the observed differences between PAN and N-PAN accuracy in three of the four subjects for whom data have been considered in this study. This observation does not preclude, however, the possibility that some physiological event other than nystagmus was instrumental in generating differences between accuracy in PAN and N-PAN sessions for these subjects.

Support for Weber's Law, i.e., that differences between the standard and adjusted stimuli in the Method of Average Error are related to the magnitude of the standard, remains lacking with respect to empirical findings for discrimination of blood alcohol in this study. Required are several discriminations within each of several stimulus ranges extending over a large portion of the non-lethal aspect of the blood alcohol dimension, e.g. 0-40 mg/100 ml. In any case, the discrimination errors found for the low- and mid-ranges of blood alcohol are of interest with respect to the hypothesis that PAN I constitutes an effective stimulus in the discrimination of blood alcohol.

Implications for the Understanding of Alcohol Intoxication Phenomena

Positional alcohol nystagmus I (PAN I) has been demonstrated to correlate highly with levels of alcohol in the blood, as predicted by the research of Aschan et al. (1956) and Goldberg (1970). Furthermore, PAN I may represent, under certain conditions, a sufficient discriminative stimulus for the successful acquisition of a stimulus-response-reinforcer (S-R-S) relationship in the discrimination of levels of alcohol in the blood. Whether or not PAN I is available to verbal awareness is unanswered at the present time because of methodological problems concerning the measurement of awareness. Nonetheless, it is

probable that alcoholic subjects can employ PAN I, or some other response to the PAN body position employed in this study, in discriminating between levels of alcohol in the blood.

The correlation between PAN I and blood alcohol in this study suggests that nystagmus may exemplify the changes taking place in the central nervous system resulting from alcohol ingestion. If so, the ongoing level of nystagmic eye movements in drinking individuals could serve as an indicator of the degree of influence being exerted on the CNS by alcohol circulating in the blood. Intoxication phenomena are related tenuously to blood alcohol, as has been pointed out by Naitoh (1972). For instance, the degree of acute disturbance due to alcohol ingestion depends upon the position of the individual on the blood alcohol curve, that is, whether the level of alcohol in the blood is on the ascent, at asymptote, or on the descent. Because the present research suggests that humans can be trained to discriminate between levels of positional alcohol nystagmus, it is reasonable to expect that subjects could be trained in detecting acute CNS impairment, through detection of PAN I, in order to make decisions about complex and dangerous functioning, such as driving an automobile.

The extensiveness of heavy drinking duration may be a limiting factor in the ability to train subjects in

the detection of levels of nystagmus and blood alcohol. This conclusion is based on the finding that the two subjects with the most previous hospitalizations for heavy drinking were unable to acquire accurate estimation of blood alcohol, using nystagmus, while the remaining three subjects, none of whom had extensive histories of heavy drinking, were successful at learning to discriminate levels of alcohol in the blood.

Implications for the Modification of Heavy Drinking

Alcoholics acquired the ability to discriminate between levels of alcohol in the blood, within the conditions of the present study. Those conditions included the unsuccessful attempt at minimization of taste stimuli in order to reduce the ability of the subjects to respond to taste cues. This condition was included for two reasons. First, taste could have confounded seriously the assessment of positional alcohol nystagmus in the discrimination of blood alcohol. Secondly, from a clinical point of view, the use of taste as a cue to blood alcohol is undesirable because of the usual drinking practice of consuming several drinks over a period of time. The use of taste would require knowledge of absorption and elimination functions, as well as recall of previous levels of blood alcohol in the drinking session.

Another condition of the present study was the elimination of multiple feedback for blood alcohol within a session. This condition was intended to minimize previous feedback as a determinant of subsequent estimates within a session.

That PAN I can serve as an important determinant of accuracy in the discrimination of blood alcohol seems tenable as a result of this study. Despite attempts at minimizing the taste and previous feedback variables, each probably accounted for much of the variability in two of the subjects in this study.

It is recommended that training in discrimination of blood alcohol preclude the use of multiple feedback of blood alcohol within a session. A history of multiple feedback most probably can render difficult continued accuracy in estimation once the feedback has been removed, even in the presence of nystagmus, because of dependence on the feedback which precedes estimation. Thus, following one or more drink administrations, only one estimation-feedback trial is recommended per session.

An attempt at intensifying nystagmus events could make PAN I a more effective stimulus for accuracy in estimation of blood alcohol. For example, an auditory signal could be programmed so as to increase with nystagmic beats in the predicted direction. By making PAN I a stronger stimulus, subjects could acquire skills at

discrimination of blood alcohol more rapidly and consistently. The arrangement of powerful contingencies of reinforcement for detection of nystagmus could increase the use of these stimuli in estimation of blood alcohol.

One final comment concerns the possibility, on the basis, of this study, that individuals with extremely long and severe histories of excessive drinking may not acquire accurate discrimination of blood alcohol as rapidly as individuals with less severe histories. The necessity for a more systematic investigation of this relationship is suggested.

BIBLIOGRAPHY

Aschan, G., Bergstedt, M., Goldberg, L., and Laurell, L. Positional nystagmus in man during and after alcohol intoxication. Quarterly Journal of Studies on Alcohol, 1956, 17, 381-405.

Bigelow, G., Cohen, M., Liebson, I., and Faillace, L. A. Abstinence or moderation? Choice by alcoholics. Behaviour Research and Therapy, 1972, 10, 209-214.

Bykov, K. M. The cerebral cortex and the internal organs. W. H. Gantt (Trans. and Ed.) New York: Chemical Publishing, 1957.

Cohen, M., Liebson, I. A., and Faillace, L. Controlled drinking by chronic alcoholics over extended periods of free access. Psychological Reports, 1973, 32, 1107-1110.

Conger, J. J. The effect of alcohol on conflict behavior in the albino rat. Quarterly Journal of Studies on Alcohol, 1951, 12, 1-29.

Goldberg, L. Effects of ethanol in the central nervous system. In R. E. Popham (Ed.), Alcohol and Alcoholism. Toronto: University of Toronto Press, 1970, 42-56.

Guilford, J. P. Fundamental statistics in psychology and education. New York: McGraw-Hill Book Company, 1965.

Harris, T. and Balster, R. L. Analysis of the function of drugs in the stimulus control of operant behavior. In T. Thompson and R. Pickens (Eds.), Stimulus properties of drugs. New York: Appleton-Century-Crofts, 1971.

Hull, C. L. Differential habituation to internal stimuli in the albino rat. Journal of Comparative Psychology, 1933, 16, 255.

Hunt, G. M. and Azrin, N. H. A community-reinforcement approach to alcoholism. Behaviour Research and Therapy, 1973, 11, 91-104.

Lemere, F. and Voegtlin, W. L. An evaluation of the aversion treatment of alcoholism. Quarterly Journal of Studies on Alcohol, 1950, 11, 199-204.

Lemere, F., Voegtlin, W. L., Broz, W. R., O'Hollaren, W. E., and Tupper, W. E. Conditioned reflex treatment of chronic alcoholism: VII. Diseases of the Nervous System, 1942, 3, 243-247.

Lovibond, S. H. and Caddy, G. Discriminated aversive control in the moderation of alcoholics' drinking behavior. Behavior Therapy, 1970, 1, 437-444.

Mills, K. C., Sobell, M. B., and Schaefer, H. H. Training social drinking as an alternative to abstinence for alcoholics. Behavior Therapy, 1971, 2, 18-28.

Naitoh, P. The effect of alcohol on the autonomic nervous system of humans: Psychophysiological approach. In B. Kissin and H. Begleiter (Eds.), The biology of alcoholism. New York: Planum Press, 1972.

Nsamba, C. and Al-Marashi, M. S. H. Nystagmus in alcoholics. Quarterly Journal of Studies on Alcohol, 1972, 33, 706-713.

Overton, D. A. Discriminative control of behavior by drug states. In T. Thompson and R. Pickens (Eds.), Stimulus properties of drugs. New York: Appleton-Century-Crofts, 1971.

Razran, G. The observable unconscious and the inferable conscious in current Soviet psychophysiology: Interoceptive conditioning, semantic conditioning, and the orienting reflex. Psychological Review, 1961, 68, 81-147.

Schuster, C. R. and Brady, J. V. The discriminative control of a food-reinforced operant by interoceptive stimulation. In T. Thompson and R. Pickens (Eds.), Stimulus properties of drugs. New York: Appleton-Century-Crofts, 1971.

Silverstein, S. J., Nathan, P. G., and Taylor, H. A. Blood alcohol level estimation and controlled drinking by chronic alcoholics. Behavior Therapy, 1974, 5, 1-15.

Sobell, M. B. and Sobell, L. C. Individualized behavior therapy for alcoholics. Behavior Therapy, 1973, 4, 49-72(a).

Sobell, M. B. and Sobell, L. C. Alcoholics treated by individualized behaviour therapy: One year treatment outcome. Behaviour Research and Therapy, 1973, 11, 599-618(b).

Vogler, R. E., Compton, J. V., and Weissbach, T. A. Integrated behavior change techniques for alcoholics. Journal of Consulting and Clinical Psychology, 1975, 43, 233-243.

Wallgren, H. and Barry III, H. Actions of Alcohol. Vol. 1. New York: Elsevier Publishing Company, 1970.

Wilder, J. Basimetric approach (law of initial value) to biological rhythms, Annals of the New York Academy of Science, 1962, 98, 1211.

Woodworth, R. S. and Schlosberg, H. Experimental psychology New York: Holt, Rinehart and Winston, 1954.