# PROPRIOCEPTIVE RESPONSES UNDER RISING AND FALLING BAGS: A TEST OF THE MELLANBY EFFECT

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## Abstract:

This study examined proprioceptive responses under equivalent rising and falling blood alcohol concentrations (BAC), using a repeated-measures design. Seven volunteer subjects, 21 to 35 years of age, participated in the study. After alcohol consumption, BAC readings were obtained every 5 minutes, and the proprioceptive responses were measured at the following BAC levels (in %): 0 (baseline), rising 0.05, 0.075, 0.1, falling 0.075, and 0.05. The analysis focused on the comparisons of these measures at the equivalent rising and falling 0.05% and at the 0.075% BACs. Results showed that the proprioceptive response was less accurate during the rising than the falling BACs.


## Article:

Numerous studies have examined impairment of perceptual motor performance under the influence of alcohol. Findings suggest that the relationship between the blood alcohol concentration (BAC) and the performance is not linear (Moskowitz & Robinson, 1988). Researchers (Carpenter, 1962; Nicholson, Wang, Airhihenbuwa, Mahoney, Christina, & Maney, 1992; Young, 1970) have indicated that motor performance is differentially impaired at a given level of BAC according to whether the BAC is rising or falling. This is known as the Mellanby effect (Mellanby, 1919).

Although the basis for the Mellanby effect is widely speculated, only a few empirical studies have attempted to test this effect (Carpenter, 1962; Moskowitz, Daily, & Henderson, 1974; Wang, Nicholson, Airhihenbuwa, Mahoney, Fitzhugh, & Christina, 1992; Young, 1970). These studies were designed to measure motor performance during both the rising and falling phases of BAC after the subjects consumed various amounts of alcohol. The findings seemed to be consistent with what the Mellanby effect suggested—that performance was more impaired when the BAC was rising than when it was falling. However, these studies did not measure performance at the equivalent levels of BAC during the rising and falling curves. Consequently, the comparison of performance may not have occurred at the equivalent levels of BAC. Thus, the prior studies of the Mellanby effect were inconclusive. In this study testing the Mellanby effect was done by measuring the performance at the equivalent rising and falling BACs. The dependent variable was a linear movement since this measure was not found in the alcohol and motor performance literature.

## METHOD

### *Subjects*

Seven paid male volunteer subjects between the ages of 18 to 35 years participated in this study. Potential subjects were excluded for the following reasons: abstainers or individuals who drank less than twice a year, a family history of alcoholism, drinking practices of more than 1.5 times the national average of 27.8 ml/day, and obviously overweight subjects. All subjects were asked to complete the Khavari Alcohol Test to quantify their drinking experiences (Khavari & Farber, 1978). The selected subjects received a complete physical examination by a physician and were required to sign the subject's consent form before they participated in the study.

### *Measures and Apparatus*

Alcoholic beverages, mixed in a ratio of four parts orange drink to one part ethanol, were given to each subject at 1.23 g of 95% U.S.P. alcohol per kg of body weight. The BACs were measured using an intoxilyzer (Model 4011A5-A) operated by certified police officers. The proprioceptive response was taken at the following BAC percents: 0 (baseline), rising 0.05, 0.075, 0.1, falling 0.075, and 0.05.

The proprioceptive response was obtained using a linear movement apparatus. The apparatus consisted of a handle mounted on a pipe using smooth, precision bearings. During the test, the subject was blindfolded and with his right hand held onto the handle of the apparatus. The investigator guided the subject's hand to 10 inches (criterion) distance. Then the subject's hand was moved back to the starting point and the subject was asked to replicate the distance. On each trial, the starting point was different so that the subject could only use distance cues, not both distance and position cues, to replicate the movement. On each trial the absolute difference in distance from the criterion was recorded, with higher scores indicating less accurate response. It is important to note that the subject did not receive knowledge of results (KR) after each trial. Previous studies indicated that learning did not take place without KR when blindfolded subjects performed linear-positioning tasks (Bilodeau, Bilodeau, & Schumsky, 1959; Newell, 1974). In total, measurements on 10 trials were recorded and the mean of these 10 trials was used for subsequent statistical analysis. The subjects were tested pre- and post-alcohol consumption and so served as their own controls. A placebo condition was not included in this study. Since the measurements were taken at specific BAC levels, it would be inappropriate for the placebo condition (without BACs) to use the same testing protocols as that of the alcohol condition.

### *Procedure*

Before the testing began, a pilot test was conducted on two subjects to familiarize the investigators and project assistants with the testing procedures and equipment. Each testing session started at approximately 9 a.m. The subjects were instructed not to eat anything for breakfast and to refrain from eating or drinking (except water) from 10 p.m. the night before. They were asked to refrain from alcohol or drugs 24 hours prior to the testing session.

Upon arriving at the laboratory, the subject's weight and the baseline breath alcohol were taken. The subject was allowed 10 practice trials of the proprioceptive task before 10 recorded trials were given. Then the subject was served the alcoholic beverage and was instructed to consume it within 30 minutes. Upon finishing the beverage, the subject thoroughly rinsed his mouth with lukewarm water to remove residual alcohol. After 20 minutes, the first breath-alcohol sample was taken and when the reading reached approximately 0.05%, the proprioceptive responses were recorded immediately. Otherwise, the breath-alcohol test was repeated every 5 minutes until the reading reached 0.1%. The same recording procedures were used throughout all of the BAC levels. A nurse-clinician was present during the entire testing session. Subjects were escorted home after their BACs dropped below the 0.015% level.

### *Data Analysis*

The mean of 10 trials at each BAC level was calculated for each subject and used in data analysis. To examine the over-all difference of the proprioceptive response across all BAC levels, a one-way, repeated-measures analysis of variance was used. If an over-all difference was found, follow-up comparisons were made between each BAC level and the baseline phase (pre-alcohol control). To control for an inflated error rate associated with multiple comparisons, the Dunnett adjusted $t$ value was adopted (Roscoe, 1969). With standard paired-t comparison, significance is claimed at $p<.05$ level ($df = 6$) when the $t$ ratio reaches 2.45. In this study, the Dunnett-adjusted $t$ value became 3.60 ($df = 6$, $p<.05$) when each of the five BAC phases was compared with the baseline. To test the Mellanby effect, paired t-test comparisons were made on the dependent variable between the rising and falling 0.05% of BAC and between the rising and falling 0.075% of BAC.

## RESULTS

The means of proprioceptive errors (responses minus criterion) are plotted in Fig. 1 to display the trend of change at various BAC levels. The one-way analysis of variance indicated an over-all difference ($F_{5,30}$= 96.43,

$p < .0001$). The comparisons between each BAC level and the baseline showed that the proprioceptive scores at all BAC levels except one level were greater than at the baseline ($t_6 > 4.77$, $p < .01$). The proprioceptive score at the falling 0.05% was not significantly different from the baseline score ($t_6 = 1.00$, $p > .05$). The comparison between the rising and falling 50 mg/dl BAC was not significant ($p > .05$).

The comparison of the proprioceptive errors between the rising and falling 0.05% showed that the rising BAC was associated with greater proprioceptive errors than the falling BAC ($t_6 = 4.04$, $p < .007$). The difference in the proprioceptive scores at the rising and the falling 0.075% was more substantial ($t_6 = 8.65$, $p < .001$); see Fig. 1.

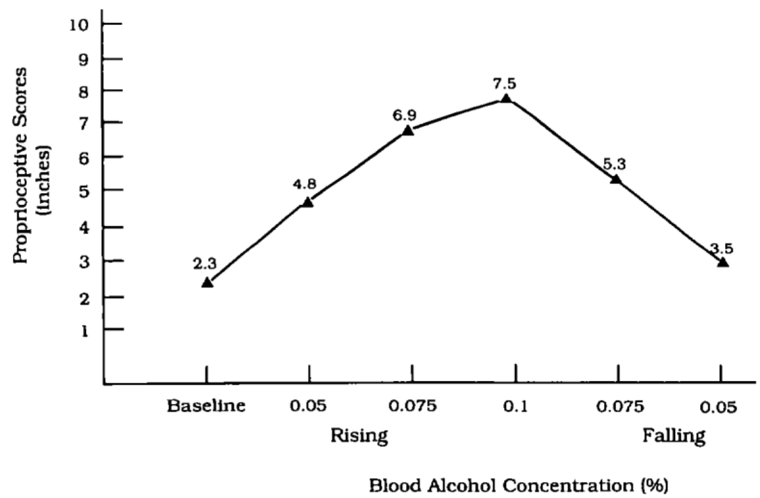


FIG. 1. Proprioceptive error scores (response-criterion 10) before and after alcohol consumption

## DISCUSSION

This study presented empirical evidence to support the speculation, known as the Mellanby effect, that alcohol differentially impairs behavior according to whether the level of BAC is rising or falling. Data showed that at two given levels of BACs (i.e., 0.05% and 0.075%) measured in this study, the proprioceptive responses were less accurate when the BAC was rising than when it was falling. The results of the present study may have illustrated why conflicting findings about a motor performance while under the influence of alcohol can arise if rising and falling BAC levels were not distinguished (Moskowitz & Robinson, 1988). For example, if the proprioceptive response had simply been tested during the rising 0.05% of BAC, then significant decrement in the response would be observed; however, if the measurement was obtained during the falling 0.05% of BAC, the opposite conclusion would be reached.

Proprioception is regarded as fundamental to human proficiency in a man-machine system (Adams & Creamer, 1962; Klein & Posner, 1974). It is generally agreed that proprioception performs a regulatory function for the overt response which aids the individual in discriminating a correct movement from an incorrect one, so it is acknowledged as an important contributor to skilled motor behavior (Adams, 1961; Adams & Creamer, 1962; Adams & Xhignesse, 1960). The impaired proprioceptive function under the alcohol influence seemed to partly explain why alcohol can decrease human performance (Burns & Moskowitz, 1980; Collins, 1980; Lubin, 1977; Moskowitz & DePry, 1968; Sutton & Burns, 1971).

As Moskowitz, *et al.* (1974) pointed out, that one possible confounding factor in past studies of the Mellanby effect was the failure to control for a learning effect. Typically, subjects' performance was first examined during the rising BAC curve and then again during the falling BAC curve. The tests obtained during the rising BAC curve might provide additional practice before tests during the falling BAC curve. To counterbalance for learning effect, half of the subjects should be tested on the rising BAC curve on one day and then on the falling BAC curve on the second day. Another half of the subjects should be tested in the reverse order (Moskowitz, *et al.*, 1974). Although our study did not adopt such a design, prior studies using the linear positioning task showed no learning effect when blindfolded subjects were not provided with KR after each trial (Bilodeau, *et al.*, 1959; Newell, 1974). Therefore, the learning effect was not considered present in this study.

In conclusion, findings seem to encourage researchers in pursuing the study of neuromuscular mechanisms that underlie the proprioception. Further, no mechanism is known that causes performance to be more impaired while the BAC curve is rising and less impaired while the BAC curve is falling. Although researchers (Wang, *et al.*, 1992; Young, 1970) have speculated that the human body has an adaptation system that can resist the continuous effect of alcohol on the nerves, further research is necessary before such a mechanism is fully understood.

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