The Mellanby Effect in Moderate and Heavy Drinkers

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INTRODUCTION

The Mellanby effect is named for E. Mellanby, who, in 1919, reported that the behavioural impairment at a given blood alcohol level was greater when the blood alcohol level was rising than when it was falling. While many subsequent studies have replicated this example of acute tolerance, estimates of its magnitude have been compromised by experimental problems. For example, many studies have determined blood alcohol levels (BAC) using venous samples whose alcohol level lags in time compared to arterial and brain levels during the rising BAC phase. Other studies have failed to control for practice effects since, typically, they have measured subjects sequentially on a task — first during the rising and then on the falling phases of a single administration. Clearly, during the falling period, subjects will have been more practised on the task.

Another problem has been that many of these studies have utilised extremely rapid rates of administration of alcohol with doses larger than 1 gm/kg bodyweight, given in five to twelve minutes. Since rapid intake is associated with an initially greater degree of impairment, it would be hard to estimate the additional deficits associated with the rising BAC phase in normal alcohol consumption.

This current study attempted to control the factors discussed above. It had one additional feature. Half the subjects were very heavy drinkers and half were moderate drinkers, so as to determine whether there was an interaction between the development of acute tolerance to alcohol and the existence of chronic tolerance, typically found in the heavy drinker.

In the study, practice effects were balanced by requiring subjects to attend two experimental sessions, once for testing on a rising BAC curve and once for testing on a falling BAC curve. Half the subjects were first tested on a rising and then a falling BAC phase, and the opposite was done for the other half of the subjects. Accurate estimates of brain alcohol level were obtained by use of a breath sampling gas chromatograph. Breath alcohol levels are in equilibrium with arterial blood alcohol levels which are in turn in equilibrium with brain alcohol levels. Thus, unbiased estimates of brain BAC were obtained for both rising and falling blood alcohol phases. Alcohol administration was given at rates more typical of social drinking situations, ranging between 0.32 and 0.35 g alcohol per kg bodyweight per hour.

The study utilised five behavioural performance measures: hand steadiness while standing and sitting; body sway in the lateral and anterior-posterior planes; and finally, a divided attention task. Due to technical difficulties, the divided attention task produced unreliable data and results are not included.
METHOD

Subjects

Forty male subjects were used: twenty moderate drinkers and twenty heavy drinkers. These categories were defined by alcohol quantity-frequency consumption scales and personal interviews regarding recent drinking history.

Response Measures

Hand steadiness was measured by amount of time a metal stylus inserted in a hole made contact with the metal plate. This measure was taken both while standing and while sitting. Body sway was measured by attaching two strings at chest height to the subject's side and back and measuring the excursions of the string in the subject's anterior-posterior plane and in the lateral plane.

Alcohol Treatments

Alcohol was administered in mixed drinks containing 80-proof vodka. It was intended that moderate drinkers consume sufficient alcohol to achieve a BAC of 0.10% and heavy drinkers achieve 0.15%. The alcohol treatments administered were designed to produce increases of roughly 0.02% BAC per hour in moderate drinkers. In heavy drinkers the treatments were also designed to produce increases of 0.02% BAC per hour until they reached 0.10% BAC, and then the alcohol rate was increased slightly so BACs were to increase 0.025% per hour. Thus, moderate drinkers reached their BAC levels in, roughly, five hours, and heavy drinkers in, roughly, seven hours, during the day when testing was on the rising BAC. BAC samples were taken at frequent intervals. Behavioural testing was timed by frequent breath sampling so as to produce performance measures at 0.01% BAC.

RESULTS

BAC levels dropped 0.020% per hour for heavy drinkers and 0.017% per hour for moderate drinkers on the falling BAC test days. This difference is to be expected in terms of the increased metabolism rate for alcohol typically found in chronically tolerant heavy drinkers.

It was desired that the rate of change of alcohol levels be similar during the behavioural testing on the rising and falling phases. During the rising BAC test days, BAC levels rose 0.023% per hour for the moderate drinkers and 0.024% for the heavy drinkers. Thus, the rates of change of alcohol level during the rising BAC test sessions were, roughly, 20 to 25 per cent greater than on the falling BAC test days.

Figure 1 shows performance scores for all subjects, both heavy and moderate drinkers, on the four behavioural response measures for the conditions of rising and falling BAC at increments of 0.01% changes in BAC level plus an initial pretest level. It can be seen that the data supports the existence of the Mellanby effect in that performance decrement was always greater at every BAC level during the rising BAC test days in contrast to the falling BAC test days. The data was tested for statistical significance using a repeated measures multivariate analysis of variance based on a linear hypothesis model, and the difference due to the rising and falling curve was found significant for all response measures. It should be noted, however, that the difference in resistance to impairment produced by testing on the falling versus the rising BAC phase is quite small, equivalent in effect to between 0.01% and 0.02% differences in BAC level.
Figure 1  Performance of four behavioural measures as a function of BAC for rising and falling BAC phases.

Figure 2 shows differences in performance decrements at various BAC levels as a function of whether the subject is a heavy or moderate drinker. It can be seen that the experienced drinker is more resistant to the effects of alcohol.

It might be asked whether the existence of chronic tolerance in the heavy drinker would affect the development of acute tolerance, as expressed in the Mellanby phenomenon.
Figure 2  *Performance of heavy and moderate drinkers as a function of BAC.*

Figure 3 shows performance during the rising and falling BAC phases separately for heavy and moderate drinkers on one of the measures, i.e. lateral sway. The results here are typical of all the performance measures. It can be seen that there is as much or greater development of acute tolerance in the chronically tolerant heavy drinkers as in the non-tolerant
moderate drinkers. Clearly, there is evidence for the development of acute tolerance as expressed in the Mellenby phenomenon, and the acute tolerance occurs independently of the existence of the chronic tolerance in the heavy drinker.

![Graph showing blood alcohol concentration for heavy and moderate drinkers on lateral sway]

The results of this aspect of the study are in conflict with the suggestion offered by Jellinek (1960) that chronic heavy drinkers would be expected to show less acute tolerance and specifically a smaller Mellenby effect than moderate drinkers. This suggestion was based on the belief that the chronic tolerance induced by heavy drinking would have protected the drinker from some of the impairing effects of alcohol from the very start of the drinking session. The results herein obtained conform more closely with the expectations of the theory of tolerance developed by LeBlanc, Kalant, LeBlanc, and Gibbins. They propose that the result of the development of tolerance by heavy chronic drinking is a change in the rate and degree of final amount of acute tolerance exhibited at each drinking session, in comparison with that shown by a naive or moderate drinker. Thus both moderate and heavy drinkers would begin to exhibit behavioral impairment at approximately the same threshold level in the rising BAC curve. However, the rate of increase in impairment for the heavy...
drinker would be slower and reach a lower level at a given BAC level than for a moderate drinker.

It might be wondered why the Mellanby effect is quite small in size in this study, in comparison with larger differential effects for rising and falling BAC curves reported in other studies. It was our hypothesis that this was due to the difference in the rate of administration of alcohol. To test this, Moskowitz and Burns performed an additional study in which performance decrement under alcohol was examined as a function of the rate of drinking for five different groups. The study determined that the more rapid the rate of drinking the greater the degree of performance decrements at the same BAC level.

REFERENCES