Acute tolerance to alcohol: changes in subjective effects among social drinkers

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Abstract. The development of acute tolerance to the subjective effects of alcohol was examined in 32 social drinkers. Measures were made of self-reported level of intoxication and responses to questions from the alcohol scale of the Addiction Research Centre Inventory. The time to peak self-reported intoxication level was found to be 20 min earlier than the time to peak blood alcohol concentration. Changes from the ascending to the descending limb of the blood alcohol curve were found with five of the ARCI questions. In all cases the proportion of alcohol-typical responses was lower on the descending portion of the curve, even though blood alcohol levels were equivalent. Further analyses examined the effects of prior drinking history on the development of acute tolerance. Peak self-reported intoxication levels were significantly lower and occurred earlier for heavier drinkers. Furthermore, for four of the five ARCI questions heavier drinkers were less likely to give an alcohol-typical response than lighter drinkers on the ascending portion of the curve.

Key words: Acute tolerance – Alcohol – Drinking history – Subjective effects

Acute tolerance to alcohol is usually demonstrated by showing that there is a greater effect on the ascending limb of a blood alcohol curve relative to its effect on the descending limb, or a gradual decrease in effect with constant blood alcohol concentration. Since Mellanby (1919) first observed this phenomenon, it has been confirmed with a wide range of physiological and behavioural measures of alcohol effect in both animals and humans. For example, human studies have shown acute tolerance with standing steadiness (Hurst and Bagley 1972), reaction time (Young 1970), recall (Jones 1973), numerical coding of letter charts (Hurst and Bagley 1972), arithmetic (Ekman et al. 1963) and other tasks.

More recently, Radlow and Hurst (1985) predicted that self-reports of alcohol effect should also be subject to acute tolerance. If this is the case, then, for the same BAC, subjects should report a stronger alcohol effect on the ascending part of the curve (i.e., before the peak alcohol concentration is reached) compared to the descending part. In their study subjects were given a self-rating scale between 0 and 20 and asked to rate how intoxicated they felt: “0” represented no effect whilst “10” was a little high and “20” double that effect. Radlow and Hurst (1985) found that the peak subjective alcohol effect, as measured by magnitude estimation (Ekman et al. 1963), occurred 24 min before the time of peak BAC. The alcohol-effect curve rose more sharply and peaked earlier than the BAC curve. It declined rapidly in the later part of the session. Other data are consistent with their findings. For example, Myrsten et al. (1975) also found that the peak alcohol effect occurred earlier than the peak BAC and that the alcohol effect declined more rapidly than the blood levels.

The differential effect that alcohol has on the ascending and descending limbs has also been observed with measures of mood. Numerous studies have found that the effects of alcohol are biphasic. During the ascending limb most subjects describe themselves as friendly and vigorous. In contrast, subjects report feeling tired, and somewhat depressed and anxious during the descending limb (Ekman et al. 1964; Babor et al. 1983; Lukas et al. 1986). Thus, in addition to quantitative differences in subjects’ self-report of alcohol effect there are more global changes in self-reports of mood.

Several factors have been suggested to affect acute tolerance development. One such factor is the behaviour being measured. That is, both the magnitude and time course of acute tolerance may vary according to the type of task involved. For example, the degree of adaptation for visual masking tasks (Moskowitz and Burns 1976) and automobile driving ability (Loomis and West 1958) is marginal, while performance on numerical coding and standing steadiness tasks may show about 40-50% recovery on the descending limb from the impairment on the ascending limb (Hurst and Bagley 1972). Vogel-Sprott (1979) found that subjects’ performance on a letter coding task indicated acute tolerance, whilst the same subjects showed no evidence of acute tolerance with a pursuit rotor task.

The development of acute tolerance may also be affected by a person’s prior drinking experience. Jellinek (1960) suggested that acute adaptation may occur faster in heavier drinkers. That is, the degree of chronic exposure affects acute adaptation to alcohol. An experiment by Banks et al. (1979) gives some support to this view. When comparing a single heavy drinker with several people who drank lesser amounts, it was found that the self-reported level of intoxication of the heavy drinker peaked earlier and was not as high as was the case with lighter drinkers. The decline of BAC level after the peak was much steeper for the heavier drinker. Although limited by sample size, it suggests a faster
rate of development of acute tolerance for heavier drinkers compared to light.

The present study was designed to evaluate the effects of drinking history on the development of acute tolerance using a larger sample of subjects. Two measures were employed. One was the self-report of intoxication (magnitude estimation) used by Radlow and Hurst (1985). As in their study, acute tolerance was measured in terms of the relationship between time to peak reported alcohol effect and time to peak BAC level. The second was a modified version of the Addiction Research Centre Inventory (ARCI) alcohol scale. A comparison was made between subjects' responses on the ascending limb and those on the descending limb. The sample consisted of moderate social drinkers, sub-divided into those at the higher end of the range and those at the lower.

**Materials and methods**

**Subjects.** Twenty-eight males and four females between the ages of 18 and 27 were recruited from the general student population at Monash University. Only moderate social drinkers—those who consumed 6–24 standard (10 ml ethanol) drinks per week—were selected as subjects. They were instructed to abstain from alcoholic beverages for 24 h and to fast for 4 h prior to the experiment. Upon conclusion of the experiment each subject received $5.00 in payment.

**Beverages.** The dose of alcohol administered was 0.85 g absolute alcohol per kilogram of body weight. It was consumed in the form of vodka (Robka label) and orange juice (Sunup label) in a ratio of 1 part of vodka to 3 parts orange juice to yield a 9.4% alcohol concentration by volume. This mixture was divided among four cups and each drink was consumed over a 5-min period. Each of the drinks progressively increased in volume but not in strength. The first drink contained 10% of the total alcohol, the second 20% of the alcohol, the third 30% and the fourth 40% of the total alcohol. This drinking format was utilised in order to slow down the approach of the peak BAC.

**Experimental measures.** In order to measure subjects' perceived degree of intoxication, they were presented with a sheet titled "self-estimated degree of intoxication". They were asked to respond on a scale from 0 to 20, where 0 represented "no effect", 10 "a little drunk", 15 "drunk", 20 "very drunk". The effect of alcohol on mood was measured by the ARCI questionnaire (Haertzen et al. 1963). Fifty true/false questions were chosen from those specifically designed to differentiate between sober and intoxicated individuals. Ten neutral questions were placed randomly throughout the list. Of the 50, 29 questions were scored positive if subjects answered "true" and 21 if subjects answered "false". Blood alcohol concentration was measured using an alcometer (Lion, model S-D2).

**Design and procedure.** The experiment consisted of one 2-h session. A 20-min drinking period was followed by a 20-min waiting period. This was necessary to avoid spuriously high blood alcohol readings due to alcohol mouth residue. At the 40-min mark (i.e., at the end of the waiting period), the first BAC reading and intoxication rating were taken. They were then recorded at regular, 10-min intervals. Each subject completed the ARCI questionnaire on both the ascending and descending limbs of the blood alcohol curve. The times for the completion of the ARCI form were based on pilot work showing that comparable blood alcohol levels were obtained between the 40- and 60-min mark and on the descending limb between the 80- and 100-min mark. The session ended at the 120-min mark and subjects were then debriefed.

**Data analysis.** In order to compare the time course of BAC with self-reported alcohol effect, the graphical technique of Radlow and Hurst (1985) was adopted. The two measures were plotted on the same graph, but with axes scaled so that peak values and zero points were matched for vertical position. This was done for the complete sample of subjects and separately for the heavier drinkers (those whose total weekly alcohol consumption fell above the median for the group—100 ml ethanol per week) and the lighter drinkers (those whose consumption fell below the median level). Heavier and lighter drinkers were also compared on the peak level of self-reported alcohol effect using a t-test.

Total ARCI scores out of 50 were analysed using a t-test to determine whether there was any difference between scores on the ascending part of the alcohol curve and those on the descending part. In addition, the data from individual questions were analysed using the McNeamar test for significance of changes (Siegel 1956).

**Results**

Curves showing changes in BAC and self-reported alcohol effect are shown in Fig. 1. Data from the complete sample (top panel) show clear evidence of acute tolerance. Firstly, the peak self-reported effect occurred approximately 20 min before the peak BAC. Secondly, the self-reported curve is above the BAC curve in the early part of the session, but below it in the latter part. Self-report declined at a slightly greater rate than BAC.

Differences in acute tolerance were found between heavier and lighter drinkers. Figure 1 shows a peak BAC for lighter drinkers at the 50-min mark, a small decline and then a return to the peak level. Self-reported alcohol effect reached a maximum at the first peak and then declined through the session. In contrast, self-reported effect was approximately constant from the 40–70-min mark for the heavier drinkers. While the maximum occurred at the 40-min mark, values only began to decline significantly 60 min after drinking ceased (the 80-min mark). The rate of decline (as measured by the slope of the self-reported effect curve) was approximately the same for both groups in the second half of the session.

There were also some differences in the absolute self-intoxication ratings. The peak rating of each subject was determined and the values averaged separately for lighter and heavier drinkers. The respective means were 13.5 and 10.9—a significant difference ($t_{15} = 6.62, P < 0.05$). Heavier drinkers had only a slightly lower average BAC level (0.075 vs 0.071).

A comparison was made between ARCI scores on the ascending and descending portions of the curve. Although there was some difference (means of 40 and 35.9, respectively), this was not significant ($t_{31} = 0.94, P > 0.05$). However, there was a significant difference for five of the individual