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Effects of a Moderate Dose of Alcohol on Intellectual Functions*

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With 1 Figure in the Text

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The aim of the present investigation was to examine the effects of a moderate dose of alcohol on intellectual functions. It is generally assumed that "complex" functions are relatively more sensitive than simpler ones to disturbances of the central nervous system, such as the action of centrally depressant drugs. In view of this hypothesis, which is supported by STEINBERG's (1954) experiments with nitrous oxide, it appears likely that intellectual functions would — on the whole — be susceptible to the action of alcohol. The data presented so far are, however, not conclusive.

The psychological research on effects of alcohol intoxication has been mainly focussed upon sensory and motor functions (e. g. GOLDBERG 1943; BJERVER and GOLDBERG 1950; VOGEL 1958; DREW et al. 1959), while intellectual functions have received relatively little attention. However, some previous studies suggest that intellectual functions may be impaired by moderate doses of alcohol (e. g. HARTOCOLLIS and JOHNSON 1956; PIHKANEN 1957; TAKALA, SIRO and TOIVAINEN 1958; ZIRKLE et al. 1959). On the other hand, the results obtained by CARPENTER et al. (1961) do not support the assumption that "higher" mental functions are particularly susceptible to alcohol[1].

The rather confused picture which the literature on effects of alcohol on psychological functions presents is certainly partly associated with the unsatisfactory experimental procedures employed in many of the earlier investigations, which make it impossible to differentiate between the effects on performance related to changes in blood alcohol and the concomitant effects of practice and fatigue. In the present experiments attempts were made to keep the blood alcohol constant throughout the period of psychological testing by means of a continuous intravenous alcohol drip. Control data were obtained from placebo experiments on the same subjects.

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[1] For earlier work in this area see e. g. KÜRZ and KRAEPELIN (1901).

A factor scale of intellectual ability was used which provided measures of four well-defined intellectual factors, the verbal, numerical, inductive and spatial factor. In addition, subjective changes were examined by a self-rating scale.

Methods

Subjects. Eight male university students participated in the experiments. Their ages ranged between 20 and 27 years and their body weights between 57 and 77 kg. They all reported having moderate drinking habits.

Alcohol administration. The experiments were carried out in the morning after a minimum of 12 hours fasting. Alcohol was given as distilled spirits ("Absolut rent brännvin", 31.6 per cent alcohol by weight) in a dose corresponding to 0.8 g alcohol per kg of body weight. The average amount of "brännvin" was 160 ml, or 51 g, of alcohol. The dose had been calculated so as to produce a blood alcohol maximum of 0.8 per mil. The whole dose was taken orally within approximately 10 min. In order to maintain the blood alcohol at a constant level during the psychological testing, an intravenous drip of about 0.1 g of alcohol per kg of body weight per hour was given as 5 per cent alcohol by weight in an isotonic glucose solution. The infusion was given in the left antecubital vein into which a teflon catheter (Barr and Soila 1960) had been introduced. The drip was started about 1 hour after the intake of alcohol and was continued throughout the 45-min testing period.

In the control condition the subjects received a drink of water and an infusion of isotonic glucose solution.

Blood alcohol determinations. Triplicate samples were taken from a finger tip immediately before, during and after the psychological testing and analysed by the micro method of Widmark (1932). The average times for the collection of samples were 83, 111 and 135 min after the alcohol intake, corresponding to 8, 36, and 60 min after the beginning of the alcohol drip.

In the control experiments exactly the same procedure for collection of blood samples was followed.

Intellectual tests. The F-test, a factor scale constructed at the University of Stockholm under the direction of Professor K. Härnqvist, was used to measure intellectual ability. There are two parallel forms, each of which consists of four tests, one for each factor; both parallel forms were used. The procedure of administration as well as the time limits were modified to suit this particular experimental situation.

The verbal factor: Opposites. Each item consists of a stimulus word and four test words. The task was to identify the test word which is the opposite of the stimulus word. Forty items were arranged in order of increasing difficulty and the score was the number of items correctly solved in 4 min.

The numerical factor: Multiplication. The task was to multiply items consisting of one 1-digit and one 2-digit number. Fifty items were arranged in order of increasing difficulty and the score was the number of items correctly multiplied in 3 min 30 sec.

The inductive factor: Letter groups. Each item consists of four 4-letter groups. Three of these groups are constructed according to a common logical principle, whereas the fourth does not follow this principle. Example: *CFDE*, GHIJ, KLMN, PQRS.

The task was to identify the group that differs from the other groups. Twenty such items were arranged in order of increasing difficulty and the score was the number of items correctly solved in 10 min.

The spatial factor: Block counting. Each item was a drawing of a block-construction and the task was to count the number of blocks. There were 25 items arranged in order of increasing difficulty and the score was the number of items correctly solved in 6 min.

In order to obtain measures of speed of performance each test was divided into four or five parts, depending upon the total number of items in the test; each part comprised an equal number of items. The subject worked continuously, but the time was noted each time he finished one part and thus 4 or 5 time scores were obtained for each test.

Subjective ratings. A self-rating scale (JONSSON: unpublished) consisting of 21 items covering emotional, motivational and cognitive reactions was used. The subject was required to judge how each item (e. g. tired, restless) applied to himself on a scale with 8 response categories ranging from "considerably less than usual" to "considerably more than usual".

Procedure. Each subject came to two sessions a few days apart. Alcohol and placebo were given to alternate subjects in order of their arrival. In order to keep effects of anticipation as constant as possible the subjects had been told in advance that they might receive alcohol in different concentrations in the two sessions.

First the subject was given a drink of alcohol or water. During the absorption phase preparations were made for the intravenous drip, which was started about 1 hour after drinking. About ten min later the first blood samples were collected and the psychological testing began. The intellectual tasks were given first, followed by the self-rating scale.

To counterbalance effects of possible systematic changes in blood alcohol during the experiment, the order of presentation was rotated so that each test appeared first, second, third and fourth an equal number of times. The second blood sample was collected after two tests and the third sample after all four tests had been completed and the rating scale had been filled in.

Results

Blood alcohol concentration. The values for mean blood alcohol during the experiment as determined by direct analysis of blood are

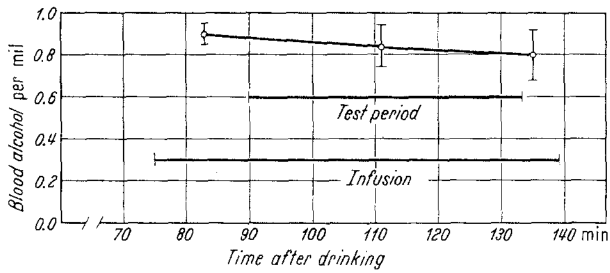

Fig. 1. Means and S. E. for blood alcohol before, during and after psychological testing

shown in Fig. 1. The alcohol dose given orally had been chosen so as to produce a maximum blood alcohol of approximately 0.80 per mil. The diagram shows that this level had been exceeded at the beginning of the test period, the average value obtained being 0.90 per mil. The amount of alcohol infused did not completely counteract a decrease in blood alcohol; by the end of the experiment the average value had dropped to 0.80 per mil.

Table 1. *Means and S. E. for number of items correctly solved during alcohol and placebo conditions*

Test	Alcohol	Placebo
Verbal	33.88 ± 1.65	34.75 ± 1.21
Numerical	39.88 ± 3.09	44.63 ± 1.88
Inductive	15.25 ± 0.96	16.00 ± 1.02
Spatial	13.00 ± 1.53	17.38 ± 1.72

Effects on number of items correctly solved. Table 1 shows the mean number of items correctly solved in the four tests under the two experimental conditions. Performance was consistently inferior in the alcohol condition, but in the verbal and inductive tests the differences were small and not statistically reliable. Performance in the numerical and spatial tests was significantly impaired by the alcohol. The t-values, based on intra-pair mean differences, were 2.50 for the numerical test ($P < 0.05$), and 5.09 ($P < 0.005$) for the spatial test.

Differential effects on performance in various tests. In order to make possible a comparison of the extent of impairment in the four tests the measures of performance changes were standardized by computing for each test the mean difference score

$$D = \frac{M_A - M_P}{SD_P},$$

where M_A is the mean score during alcohol, M_P the mean score during the placebo, and SD_P the standard deviation for the placebo condition. The difference scores thus obtained (Table 2) show that there were considerable differences in performance in the two conditions in the numerical and spatial tests, and small differences in the verbal and inductive tests.

Table 2. *Standardized mean difference scores for number of items correctly solved during alcohol and placebo conditions*

Test	Difference score
Verbal	−0.06
Numerical	−1.08
Inductive	−0.29
Spatial	−0.98

Table 3. *Median time scores in the alcohol condition expressed as per cent of the corresponding scores in the placebo condition*

Test	Successive parts in tests			
	I	II	III	IV
Verbal	101.6	78.9	115.0	102.4
Numerical	101.7	104.2	93.0	97.6
Inductive	95.3	86.4	123.1	77.2
Spatial	119.5	102.6	77.7	120.5

In order to determine if the four difference scores were significantly different from each other standardized *individual* difference scores were calculated (cf. Frankenhaeuser and Beckman 1961) for each of the four tests. The four sets of scores thus obtained were submitted to a one-way analysis of variance. However, a statistically significant difference between the extent of impairment caused by alcohol in the various tests could not be demonstrated.

Differential effects on speed and accuracy of performance. Effects of alcohol on speed of performance were examined by computing the median time scores for each part of the four tests under each of the two conditions. Table 3 shows the time scores in the alcohol condition expressed as per cent of the corresponding time score in the placebo condition. (Since more than half of the subjects failed to complete the fifth part of the tests, results from four parts only appear in the table.) There were no systematic differences in the time scores between the two conditions.

Another measure of the effects of alcohol on speed of performance was obtained by comparing the total number of responses, whether right or wrong, in the two conditions. Table 4 shows the number of responses in the alcohol condition expressed in per cent of the number in the placebo condition. Again, the differences between the conditions were relatively small and not consistent. The difference was most marked in the numerical test, in which the speed was reduced by 6.6 per cent.

In order to assess the effects of alcohol on accuracy of performance, the number of wrong responses under each of the conditions was computed. Table 5 shows that there were consistently more wrong responses during alcohol in all tests. Again, the differences were significant for the numerical test ($P < 0.05$) and for the spatial test ($P < 0.01$), but not for the verbal and inductive tests.

Table 4. *Total number of responses during alcohol in per cent of the number of responses in the placebo situation*

Test	Per cent
Verbal	98.7
Numerical	93.4
Inductive	104.2
Spatial	101.1

Table 5. *Means and S. E. for number of wrong responses during alcohol and placebo conditions*

Test	Alcohol	Placebo
Verbal	4.13 ± 1.02	3.75 ± 0.85
Numerical	3.13 ± 0.54	1.38 ± 0.58
Inductive	3.25 ± 0.78	1.75 ± 0.49
Spatial	9.38 ± 1.54	4.75 ± 1.81

Subjective reactions. A comparison of the self-ratings during the two experimental conditions showed that the subjects felt significantly *less concentrated* ($P < 0.02$), *less clear-headed* ($P < 0.01$), *less energetic* ($P < 0.05$), and *more "distant"* ($P < 0.01$) in the alcohol condition. There were no marked differences in such aspects of mood as "happy", "carefree", "friendly", "irritated", "restless".

Comments

The infusion technique adopted in the present experiments made it possible to obtain, within one experimental session, measures of four different performances, while the blood alcohol remained relatively constant. Another advantage of the infusion technique is that it provides a satisfactory placebo situation, which is otherwise difficult to obtain in alcohol experiments (cf. NEWMAN 1935). Although the self-ratings showed significant changes only in items referring to intellectual alertness the experimenters' observations revealed that most subjects experienced an increased well-being and also became more talkative. On the whole, however, both subjective and overtly noticeable behaviour changes were relatively small. In the placebo condition four of the eight subjects reported feeling slightly intoxicated during the infusion.

There is no objective measure of the relative complexity of the four intellectual tests, but the inductive test is generally considered by far the most complex. The numerical test is usually considered the simplest one, while the verbal and spatial tests appear to be of intermediate complexity. Hence, the outcome of these experiments does not support the view adopted by some investigators (e. g. JELLINEK and MCFARLAND 1940) that more complex tasks would be more susceptible to the action of alcohol.

The present results are consistent with those of TAKALA et al. (1958) who also found an impairment in spatial and numerical tests, and with the results of CARPENTER et al. (1961) which showed reasoning to be relatively resistant to alcohol. In the present experiments there was, however, no indication of a better reasoning ability after drinking corresponding to the facilitation of higher order problem solving after small amounts of alcohol as demonstrated by CARPENTER et al.

The impairment in spatial performance is consistent with clinical observations indicating that the understanding of spatial relationships is easily disturbed in brain-injured patients. The numerical test is a typical speed-test. However, accuracy and not speed was affected, which shows that during alcohol the subjects tended to become more careless rather than slowing down.

Conclusions from the present experiment are, of course, restricted to the single dose used. It appears likely that not only the amount of disturbance, but also the pattern of action, would vary with different dose levels. Nevertheless, it is of interest to compare the effects of alcohol as manifested in this investigation with effects of other centrally depressant drugs on performance in the present tests. FRANKENHAEUSER and BECKMAN (1961) showed that inhalation of 30 per cent nitrous oxide in oxygen gave rise to a severe deterioration in the performance of all four tests. Differences in extent of impairment *between* the tests were not found. FRANKENHAEUSER and POST (1962) found that a 200-mg dose of pentobarbitone produced a statistically significant impairment of verbal performance but had no noticeable effect on the other tests. The results of these investigations seem to suggest that various central depressants have specific patterns of action on various intellectual functions.

Summary

Performance in four intellectual tests (verbal, numerical, inductive, spatial) was examined in 8 healthy subjects after the intake of a dose of alcohol corresponding to 0.8 g per kg of body weight. Attempts were made to maintain the blood alcohol at about 0.8 per mil during the period of psychological testing by means of an intravenous drip of about 0.1 g alcohol per kg of body weight per hour. Comparisons with results obtained in a placebo condition showed that performance in the numerical and spatial tests was significantly impaired by this dose of alcohol, whereas effects on performance in the verbal and inductive tests could not be demonstrated. The results indicated that accuracy was more sensitive than speed of performance to the action of alcohol at the present dose level.

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References

BARR, P.-O., and P. SOILA: Introduction of soft cannula into artery by direct percutaneous puncture. Angiology **11**, 168—172 (1960).

BJERVER, K., and L. GOLDBERG: Effect of alcohol ingestion on driving ability. Quart. J. Stud. Alcohol. **11**, 1—30 (1950).

CARPENTER, J. A., O. K. MOORE, C. H. SNYDER and E. S. LISANSKY: Alcohol and higher-order problem solving. Quart. J. Stud. Alcohol **22**, 183—222 (1961).

DREW, G. C., W. P. COLQUHOUN and H. A. LONG: Effects of small doses of alcohol on a skill resembling driving. London: H. M. Stationary Office, Med. Res. Council Mem. No. 38. 1959.

FRANKENHAEUSER, M., and M. BECKMAN: The susceptibility of intellectual functions to a depressant drug. Scand. J. Psychol. **2**, 93—99 (1961).

—, and B. POST: Catecholamine excretion during mental work as modified by centrally acting drugs. Acta physiol. scand. **55**, 74—81 (1962).

GOLDBERG, L.: Quantitative studies on alcohol tolerance in man. Acta physiol. scand. **5**, Suppl. 16 (1943).

HARTOCOLLIS, P., and D. M. JOHNSON: Differential effects of alcohol on verbal fluency. Quart. J. Stud. Alcohol **17**, 183—189 (1956).

JELLINEK, E. M., and R. A. MCFARLAND: Analysis of psychological experiments on the effects of alcohol. Quart. J. Stud. Alcohol **1**, 272—371 (1940).

KÜRZ, E., and E. KRAEPELIN: Über die Beeinflussung psychischer Vorgänge durch regelmäßigen Alkoholgenuß. Psychologische Arbeiten, Bd. 3 (Ed. E. KRAEPELIN). Leipzig: Engelmann 1901.

NEWMAN, H. W.: Alcohol injected intravenously. Amer. J. Psychiat. **91**, 1343—1352 (1935).

PIHKANEN, T. A.: Neurological and physiological studies on distilled and brewed beverages. Helsinki: Maalaiskuntien Liiton Kirjapaino 1957.

STEINBERG, H.: Selective effects of an anaesthetic drug on cognitive behaviour. Quart. J. exp. Psychol. **6**, 170—180 (1954).

TAKALA, M., E. SIRO and Y. TOIVAINEN: Intellectual functions and dexterity during hangover. Quart. J. Stud. Alcohol **19**, 1—29 (1958).

VOGEL, M.: Low blood alcohol concentrations and psychological adjustments as factors in psychomotor performance. Quart. J. Stud. Alcohol **19**, 573—589 (1958).

WIDMARK, E. M. P.: Die theoretischen Grundlagen und die praktische Verwendbarkeit der gerichtlich-medizinischen Alkoholbestimmung. Berlin: Urban & Schwarzenberg 1932.

ZIRKLE, G. A., P. D. KING and O. B. MCATEE: Effects of chlorpromazine and alcohol on coordination and judgment. J. Amer. med. Ass. **171**, 1496—1499 (1959).

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