A detailed description of all of the apparatus used, the results of the individual experiments, and a critical discussion of the technique of determining the respiratory exchange of man in short periods are given in Publication No. 216 of the Carnegie Institution of Washington.

NEURO-MUSCULAR EFFECTS OF MODERATE DOSES OF ALCOHOL

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In accordance with its widely distributed 'Tentative Plan'[1] the Nutrition Laboratory of the Carnegie Institution has organized and initiated an exhaustive experimental study of the physiological consequences of the ingestion of small doses of ethyl alcohol in man. The first year's work under the psychological part of that Plan was devoted to an investigation of the effects of alcohol on a selected group of interrelated processes covering the fundamental neural activities at various levels of the cerebro-spinal system, from the simplest reflexes of the lumbar cord to the most complex cortical arcs that we could accurately measure by available laboratory techniques.

The selection of the particular group of neuro-muscular processes for measurement was determined by the following experimental demands: (1) The systematic demand for coördinate data covering as many as possible of the fundamental psychophysiological operations. (2) The interpretative demand for the least possible inclusion of unknown and uncontrolled factors. (3) The practical demand for natural reaction forms which would be comparable in a large number of individuals without special practice, and would show relatively little practice effect as a result of the experimental repetition. (4) The technical demand for dependable quantitative methods of stimulation and registration.

Of the simple reflex arcs which are available for experimentation, the patellar reflex and the protective lid-reflex were chosen, chiefly because of their similar latency and the accuracy of their modern techniques. Our measurements of these reflexes include data concerning their latency, the extent of the muscle contraction, and the relative duration of the refractory phase. Of the more complex cortical arcs the following were selected: (1) eye-reactions to suddenly appearing peripheral stimuli, a thoroughly practiced phase of each individual's spatial adjustment; (2) speech reactions to visual word stimuli; and (3) free associations. The last two are characteristic phases of the individual's adjustment to his

social environment. The fundamental perseveration tendency was measured by the partial memorization of series of words. Sensory changes were indicated by Martin's Faradic-threshold measurements. Motor coördination was studied in the velocity and accuracy of eye-movements, and in the reciprocal innervation of the antagonistic muscles of the middle finger. Finally, pulse records (chiefly electrocardiograms from body leads) were taken either continuously or at homologous points in the various experimental processes.

The subjects consisted of two groups: a main group of college graduates who were very moderate users of alcohol, and a smaller group of out-patients of the Psychopathic Hospital who had been under treatment for delirium tremens.

Normal base lines in all cases included two normal experimental days for each subject and for each kind of experiment. One normal day came before and one after the experimental days on which alcohol was administered. In addition a 'normal of the day' was recorded for each experimental process on the days in which alcohol was given. Two alcohol doses were used, one containing approximately 30 cc. and the other 45 cc. of absolute alcohol.

All the measurements show more or less rhythmic and arrhythmic variations. In our statistical theory we assumed that, given a sufficiently large number of measurements, the normal rhythmic and arrhythmic variations will tend to compensate each other, leaving the average experimentally conditioned change relatively unaffected. In our data these average results show two particularly significant marks of reliability: (1) Similar processes are similarly affected and in similar degree. (2) In general the larger dose of alcohol shows the greater experimental effect.

The effect of alcohol was calculated in all cases by comparing the differences between the 'normals of the day' and subsequent periods on the normal and on the alcohol days. The greatest percentile effect was found in the reflexes. In the patellar reflex alcohol increased the latent time 10% while it decreased the amount of quadriceps thickening 46%. In the protective lid-reflex it increased the latent time 7% while it decreased the extent of lid movement 19%. It increased the latent time of the eye-reactions 5%; that of the speech reactions 3%. Memory and the free associations were only slightly affected. Sensitivity to Faradic stimulation decreased 14% after alcohol. The number of finger-movements decreased 9%; and the velocity of the eye-movements decreased 11% as a consequence of the ingestion of alcohol.

Quite in contrast to the general depression of the neuro-muscular

processes at all levels of the cerebro-spinal system was the effect of alcohol on the pulse-rate. Under all the experimental conditions alcohol produced a relative acceleration of the pulse. In only a few cases with the larger dose did this relative acceleration become a positive acceleration so that the pulse-rate in the periods subsequent to the ingestion of alcohol was faster than during the normal of the day; but in practically every instance alcohol prevented the regular pulse retardation that accompanied the successive periods of moderate mental and physical work on normal days. This relative acceleration averaged approximately 3%. While this effect is intrinsically small, its regularity, the large number of records, and its concomitant variation with the size of the dose give the results a high degree of probability.

The effort to determine which of the antagonistic heart-regulating mechanisms was responsible for the relative acceleration demanded an analysis of the pulse data. A comparison of the relative changes in the durations of systole and diastole (method of Hunt) led to a thoroughgoing consideration of the variations in the pulse cycles during the different experiments. The records show a consistent tendency of alcohol to decrease the mean variations amounting to an average of 19%. Since the rhythmic and arrhythmic pulse changes within the limits of our 12–second records could not have been conditioned by the relatively slow-acting accelerator, it seems necessary to regard the decrease of the mean variation after alcohol as caused by a decreased responsiveness of the inhibitor. There is some evidence in the records that this paralysis of the inhibitor is not an exclusive effect, and it is probable that various natural and experimental conditions might be found which would shift the preponderance of paralysis to the accelerating mechanism. The small amount of change, its purely relative character, and the probability that both regulating mechanisms are affected doubtless give the conditions for the confusion of the scientific traditions concerning the effect of alcohol on the pulse rate.

In conjunction with the pulse acceleration, the general neuro-muscular depression may be regarded as presumptive evidence of the effect of alcohol on organic efficiency. In none of our data is there any indication of a pure facilitation effect of alcohol. Contrary to the theory of Kraepelin, we not only found no facilitation of the motor processes, but the depression of their simplest forms in the finger and eye-movements seems to be one of the most characteristic effects of alcohol. Indeed it is exactly these effects that correlate most closely with the average of all the effects for the several subjects. Practically it seems to follow that these processes may serve as a readily accessible indicator

of individual susceptibility to alcohol. Theoretically it seems to follow that the effect on the motor coördinations indicates a central tendency of alcohol.

A full presentation and discussion of the various techniques and the resulting measurements are given in Publication No. 232 of the Carnegie Institution of Washington.

[1] Tentative plan for a proposed investigation into the physiological action of ethyl alcohol in man. Privately printed and distributed January 1, 1913.

VARIATION AND INHERITANCE IN ABNORMALITIES OCCURRING AFTER CONJUGATION IN PARAMECIUM CAUDATUM

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In view of the difficulty of interpreting from the standpoint of evolution the changes that occur in the complex phenomena of inheritance from two parents, the study of reproduction from a single parent becomes of great importance. One of the difficulties in such work is that the lower organisms, in which uniparental reproduction commonly occurs, present relatively few characteristics that are at the same time variable and hereditary, among closely related individuals; though this is a condition demanded for studies of heredity and evolution.

Certain abnormalities that appear after conjugation in the infusorian Paramecium appeared to offer a favorable opportunity in this respect. These abnormalities vary greatly in occurrence, character, and degree; at the same time they are partially heritable. This paper is a summary of an extended study of these abnormalities in relation to the problems of inheritance, variation, and racial change.

Among the progeny of a large proportion (from 36 to 81% in different experiments) of exconjugants of Paramecium caudatum, abnormalities appear frequently. These abnormalities consist of irregularities in body form and dimensions, of many diverse types. Among them are monsters due to partial or irregular fusion; single bodies some larger, some smaller than normal; and a great variety of abnormal shapes. These animals propagate by fission; some of the lines of individuals thus derived from the exconjugants are quite without abnormalities, in others under the same conditions the abnormalities reappear for generations. Thus the abnormalities are hereditary. But diversities appear also within the abnormal lines themselves. Some of the indi-