BROTHERS COLLEGE

ALCOHOL:

ITS EFFECT ON MIND AND EFFICIENCY

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FOREWORD

During the war the British Central Control Board (Liquor Traffic) appointed an advisory committee to consider the conditions affecting the physiological action of alcohol and particularly the effects on health and industrial efficiency produced by the consumption of beverages of various alcoholic strength. As first organized this was composed of well-known British physiologists, neurologists, pharmacologists and chemists who published in 1918 a small book, *Alcohol: Its Action on the Human Organism,* reviewing the scientific evidence concerning the effect of alcohol on human beings.

On the dissolution of the Central Control Board (Liquor Traffic) in 1921, the British Medical Research Council was invited by the Secretary of State for Home Affairs to reappoint the Alcohol Investigation Committee as one of its own committees. This was done and in due time (1924) the committee issued a second edition, enlarged and revised, of its report.

Two chapters of this report are of such general and practical importance in their presentation of scientific evidence as to the effect of alcohol upon the nervous system and the mind, that they are here republished in the hope that the facts stated will have the wider reading and attention that they deserve, for they are a valuable contribution to thoughtful consideration of the question of the beverage use of alcohol amid the conditions of modern life.

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Medical Research Council

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The persons whose names are starred (*) above were also members of the Advisory Scientific Committee upon the Physiological Action of Alcohol which prepared the first edition of the report, *Alcohol: Its Action on the Human Organism*. Other members of the original committee were Professor W. B. McDougall, now of Harvard University, formerly of Oxford University; the Chairman of the Central Control Board, (Liquor Traffic) Lord D'Abernon; and Sir George Newman, K. C. B., M. D., Principal Medical Officer to the Board of Education and member of the Central Control Board (Liquor Traffic).

I

Mental Effects of Alcohol

Effect of Environment on Symptoms of Drunkenness

The aspect of drunkenness which has most impressed the popular mind is that of boisterous, disordered and even violent activity of mind and body which not infrequently appears as one phase of the process of intoxication. But this phase commonly appears under social conditions which stimulate the emotions; alcohol undoubtedly diminishes the control of the intellect and the will over the emotions, and it appears not improbable that this passing phase of excitement may be sufficiently accounted for by exciting influences of the environment, the jovial company, the bright lights, the unrestrained talk and song, the general sense of festivity, which are the common setting of the feast. The conclusion indicated by laboratory tests of mental and bodily capacity is borne out by simple observation of one's self or of other subjects, if one takes successive doses of alcohol in the absence of all such

exciting influences. The first effect generally noticed is a slight giddiness or "light-headedness;" this is followed by an increasing heaviness and disinclination for all effort, soon passing into sleepiness; and this in turn, if not counteracted by any excitement coming from within or without, gives place to a heavy sleep which continues for many hours.

Feeling of Well-being Induced by Alcohol

We may notice at once that even under these conditions alcohol produces to some degree that effect which, perhaps more than any other, is the secret of its charm, its well-nigh universal attraction for the human race, namely, a sense of careless well-being or of bodily and mental comfort. In so far as this sense of well-being is of bodily origin, it is no doubt largely due to a flushing of the skin with blood that abolishes all sense of chill; but it is due also in part to a blunting of the sensibility to the small aches and pains and a thousand hardly distinguishable sense-impressions which, except in those in perfect health, contribute to tip the balance of bodily feeling-tone to the negative or unpleasant side. In so far as this effect is primarily mental, it results from the blunting of those higher mental

faculties which lead us to "look before and after and pine for what is not" and harass us with care for the future and a too sensitive self-consciousness for the present.

Appearance of Excitement Not Due to Any Stimulant Action of Alcohol

If, on the other hand, the drinker is subjected to the stimulation that comes from social intercourse he usually passes through a phase which may be justly called one of excitement, the degree of excitement depending upon the temperament of the drinker and the nature and degree of the external stimuli. But careful observation of and reflection upon the phenomena of this stage show clearly that they do not require for their explanation the assumption that alcohol stimulates the nervous system, whether directly or through the medium of other bodily organs.

The drinker's conversation and actions become less restrained; all his emotional responses are freer and fuller than in his normal state. He laughs and smiles more readily, he grows more easily angry or tender, elated or depressed, scornful or compassionate, according to the appeal of the moment. Perhaps the various emotional states into which fear enters as an element,

and which we denote by such names as anxiety, worry, care, despondency, are exceptions to this rule. This group of exceptions is readily explicable on the principle that we apply, namely, that alcohol successively weakens and suspends the hierarchy of functions of the brain, and therefore of the mind, in the order from above downwards; that is to say, in the inverse order of their development in the individual and in the race. For the emotional dispositions or capacities are a very ancient racial endowment and have their physiological seats in the basal ganglia, the lowest levels of the great brain, the part which alone is represented in the brains of the lower vertebrates. The higher intellectual faculties, on the other hand, are the latest acquired and are connected with the anatomically highest and last developed parts of the brain. Intermediate between these come, in the order of development, the sensory and skilled motor functions (and their nerve centres).

Blunting of Self-Criticism by Alcohol

Now, of all the intellectual functions, that of self-criticism is the highest and latest developed, for in it are combined the functions of critical judgment and of self-consciousness, that self-

knowledge which is essential to the supreme activity we call volition or the deliberative will. It is the blunting of this critical side of self-awareness by alcohol, and the consequent setting free of the emotions and their instinctive impulses from its habitual control, that give to the convivial drinker the aspect and the reality of a general excitement.

In the mature, well-developed mind this interplay of thought and emotion goes on under the checking and moderating influence of self-criticism; in social intercourse especially, it is constantly checked by the thought of the figure one cuts in the eye of one's fellow men. In proportion, then, as alcohol hampers this mechanism of self-control, the liberation of intellectual or emotional effects goes on at a higher rate. Normally the emotional states of anxiety, care and despondency are maintained by self-consciousness, by the repeated turning of the stream of thought to the self, its difficulties, its embarrassments, the snares and dangers that beset its course on every hand, and are far more frequently imagined and foreseen than actually encountered. Hence, when imaginative self-consciousness is dimmed, the emotions of this class are proportionately less liable to be touched to life, and in the absence of

their restraining influence, the other emotions run riot the more gaily.

Weakening of Self-Control Evident in Every Stage of Drunkenness; Most Prominent Feature of Initial Stage

Both introspectively and objectively this lack of self-control is clearly discernible in every stage of alcoholic intoxication. It is commonly counteracted in part by the subject, who becomes aware of it, by means of a deliberately increased effort of self-control; but, as the influence of the alcohol increases, this effort ceases to be continuously effective, and the drinker surprises the observer (whether himself or another) by smiling or laughing aloud at some very small joke, or by remarks or other actions which betray the suspension of his habitual self-control. And the weakening of his critical self-awareness is especially revealed by the fact that such jovial remarks as he now utters seem to him to shine with a lustre hardly perceptible to the normal mind; hence the tendency, perhaps the most characteristic and constant feature of the first stage of drunkenness, to flippant whimsical utterances, which, like the rest of the subject's behaviour, be-

tray the blunting of his critical self-consciousness and of his sense of personal responsibility.

The successive stages or phases of intoxication cannot be sharply distinguished, and every case presents its peculiar combination and succession of features, varying with the temperament and disposition and character of the individual and his circumstances of the moment. But three main stages may be broadly distinguished corresponding to the invasion by the narcotic of the three principal levels of cerebral function mentioned above. The first stage, that in which the highest or intellectual brain level is alone distinctly affected, has been described above.

Nervous Functions Involved in Second Stage of Drunkenness

The second stage is that in which the functions of the intermediate level, sense-perception and skilled movement, are invaded and disturbed. The drinker begins to show a certain clumsiness of behaviour. If he is self-observant, he notices that he is liable to make ill-adjusted movements; on setting down his glass it makes a more violent contact with the table than he had intended; on rising, he may stumble against a chair, perhaps upsetting it; on lighting a cigarette he may break

the match which he essays to strike; in speaking he may slur a word or drop an h. Each such little mishap will at first be quickly rectified, for each one may evoke the power, possessed in some degree by all and to a wonderful degree by many men, of temporarily correcting by an effort of concentration or self-control the paralyzing effects of the drug.

Emotional Instability in Second Stage of Drunkenness

At this stage also his perceptions are impaired. His field of sense-observation is narrowed; the several senses work in relative isolation from one another; the fineness of his ear, of his taste, his touch, his vision is blunted; he may momentarily see objects doubled, and becomes relatively indifferent to heat and cold, to the flavor of his food and the aroma of his wine, to the glare of the lights, the strains of the music, and the stridency of his own or his neighbour's voice. The impairment of his intellectual functions being further advanced than in the first stage, and the functions of the third or lowest cerebral level, that of the emotions and instinctive impulses, being still relatively intact, he is apt to give way to clumsy but violent displays of emotion char-

acterized by the exclusive dominance of each primary emotion in turn; and he passes quickly from anger to affection, from boisterous merriment to tears, from elated boasting to despondency, each unrestrained and unmodified by that blending of other emotions which expresses the reaction of the intellectual faculties upon them.

At this stage the drinker is apt to feel that his bodily movements occur without his initiation or intention—they escape from him rather than proceed from his will—and, in so far as he remains self-conscious, he leads a double life; his inner self, a detached observer with folded hands, watches his bodily actions, not seldom with surprise, consternation or amusement; he may, e. g., become aware of wearing facial expressions, of making gestures, or of uttering remarks, which he did not intend and cannot wholly repress, but which seem to him to be executed by his members of their own initiative.

At this stage the paralysis of the drinker's higher mental functions reveals itself clearly also in the increasing dependence of all mental and bodily activity upon external stimulation; he lives in and for the present moment only, and, if he is deprived of the stimulus of social inter-

course, he quickly lapses into dreamy somnolence or actual sleep.

Third Stage of Drunkenness

In the third stage, the intellectual processes of judgment and self-criticism and control are virtually suspended; the functions of sense-perception and skilled movement are grossly impaired, and the emotional tendencies themselves are invaded and weakened, so that only strong appeals to them suffice to evoke any response and, in their absence, the drinker sinks inert and nerveless into a heavy sleep, which lasts until the alcohol absorbed has all been oxidized.

Hypothesis That Alcohol Acts Primarily on Nerve-cell Junctions or Synapses

This succession of events, constituting the normal course of alcoholic intoxication as it appears to common observation, can be explained in general terms by an hypothesis as to the direct action of alcohol on the nervous tissue, which is suggested and supported by many physiological facts and analogies; the hypothesis, namely, that alcohol acts primarily and most powerfully not upon the nerve cells or fibres, but upon the junctions between nerve-cells, technically known as

synapses. It is now pretty well established that we may properly regard the nervous system as consisting of a vast number of vital units, the nerve-cells, each consisting of a central body and one or more slender threads or fibres; each cell having no anatomical but only a functional continuity with others. Their relations to one another may be likened to those of a crowd of people, in which each person maintains relations with his fellows and communicates with them only by the touch of hands and feet. There is much evidence to show that these points of contact are the weak points of the nervous pathways; the points that give way most readily under strain or shock and under the influence of fatigue and of various paralyzing drugs.

Why Effects of Alcohol Are First Shown on Higher Functions

Further, there is good reason to believe that in the pathways of the lower levels of the brain, those which subserve the functions first developed in the race and in the individual, the points of junction are relatively firm and open to the passage of the nervous current; while those of higher and later developed levels are less solidly organized, and that they therefore offer more re-

sistance to the passage of the nervous current, in proportion as they stand high in the scale of function and late in the order of development. If we accept this view, and if we make the further simple assumption that alcohol acts equally upon all such junctions of nerve-cells (or synapses), we have the explanation of the phenomena of drunkenness. For, by the terms of the hypothesis, the alcohol, acting equally upon all cell-junctions in the nervous system to increase their resistance to the passage of the nervous current, will first raise this resistance to the point of impermeability in those junctions in which it is normally highest, that is, in the latest developed paths of highest function; and it will progressively effect a similar paralysis of other nerve-paths in the descending order of functional dignity and complexity.

Action of Alcohol Purely Narcotic

It may be added that a review of the many laborious attempts made in recent years to determine by the methods of the laboratory the effects of alcohol on the mind and nervous system, shows that such observations harmonize well with these general conclusions; for, although some of the earlier workers on these lines believed they

had found evidence of an initial stimulating effect of alcohol, this appeared in all cases to be of but small extent and duration; and later work throws doubt upon the validity of this interpretation of the evidence and supports the conclusion that the direct effect of alcohol upon the nervous system is, in all stages and upon all parts of the system, to depress or suspend its functions; that it is, in short, from first to last a narcotic drug.

Varieties of Mental Symptoms in Drunkenness

If we have truly stated the principle according to which alcohol attacks the functions of the brain and of the nervous system generally, it will be seen that mental changes are naturally among the first of all the symptoms of derangement to appear. With small doses of alcohol, they may be the only symptoms which are noticeable; with larger, they are the earliest of the whole symptomatic train of changes. It is obvious that, though traceable by psychological analysis to one single source, namely, the blunting of that intellectual self-criticism and control which the mind normally exerts, the detailed forms which they assume will, under the manifold varieties of individual circumstance and character, appear as dis-

ordered items of behaviour almost Protean in shape and kind. Yet of these, various as they are, certain sub-types appear with such frequency, and have been so accreditably documented in carefully conducted test experiments,* as to be worth specific mention here, since they can be regarded as established marks symptomatic of alcoholic effect. In this respect they have therefore some practical importance. They may be subsumed briefly thus: (1) Uncritical self-satisfaction of the subject with his own performances, (2) disregard of occurrences and conditions normally evoking caution of act and word, (3) trespass of rules and conventions previously respected, (4) impaired appreciation of the passage of time, (5) loquacity and (6) an argumentative frame of mind.

Early Appearance of Purely Mental Effects of Alcohol

These changes of mentality actually observed in laboratory experiments directed toward study of alcoholic effect are largely confirmed by gen-

*Kraepelin: Uber die Beeinflussung einfacher psychischer Vorgänge durch einige Arzneimittel. Jena, 1893. Rivers: Influence of Alcohol and other Drugs on Fatigue. London. 1907. Partridge: Studies in the Psychology of Intemperance. New York, 1912.

eral experience. As laboratory experiments show, they may occur when the dose and degree of action of the alcohol are quite insufficient to cripple manifestly and openly the power to perform routine technical operations, such as adding figures or typewriting by a person accustomed to perform them. To attempt to specify the lower limit of dose required to produce these symptoms is probably of little value. Not only is there varying susceptibility to alcohol from person to person, and not only does, in one and the same person, the susceptibility differ according to circumstances, digestive and other, under the same dose, but intellectual self-criticism and control are strong in one person, weak in another, and, in the same person, while strong in respect of certain kinds of acts, may be weak in respect of certain others. With large doses these slighter mental effects are part of the train of symptoms passed through, as profounder degrees of intoxication are approached.

Disturbance of Higher Mental Junctions in Conditions Falling Short of Drunkenness

But a point of greater practical importance is that, without signs of intoxication in the full ordinary or in the legal sense of the term, the bear-

ing and individual attitude of mind suffer temporary change as an effect of the drug; and those in contact with the person so affected have for the time being to deal with an altered individual, whose mind lacks temporarily its normal factor of judgment and conspicuous elements of its self-control.

There is hardly any need to emphasize here the obvious fact, that the directions which these alterations tend to take commonly, even as instanced merely by the few sub-types of deviation of judgment and behaviour just mentioned, are likely to be fraught with serious consequences for the due discharge of responsibilities in all walks of practical life. Accuracy, avoidance of accidents, tactful handling of colleagues and subordinates, observance of discipline, punctuality, reticence in matters of confidence, are all obviously jeopardized; and an additional source of friction is brought to complicate the relations between the employer and the employed.

II

Alcohol and the Performance of Muscular Acts, and of the Simpler Mental Processes

In the preceding chapter we have dealt with the effects of alcohol on the general complexion of the mind and on behavior. A number of experimental inquiries have been carried out on the effects of alcohol on muscular activities, and on such simple mental processes as are susceptible of quantitative measurement in the laboratory. It will be convenient to group these together in this chapter, since, in more than one instance, the same observer has applied, to the same individual, tests which comprise measurements of skill or endurance in the performance of some co-ordinated muscular movement, measurements of the efficiency of purely mental processes, such as rapidity and accuracy in memorizing, and again tests in which it would be difficult to decide whether the mental process or the neuromuscular co-ordination was the more important factor in the result.

Complexity of Muscular Acts

The effect produced by alcohol on the performance of muscular work is not so readily determinable as might at first sight appear. The performance of a muscular act, even of a simple kind, involves a number of processes. The actual contraction of the muscle is only the final step in a series of events. The action of the muscle has invariably to be called forth by recurrent nervous action, and this nervous action includes, even in the simplest voluntary act, a linked series of processes with which many parts of the nervous system are concerned.

Influence of Alcohol on Their Performance Due to Action on Nervous System, and Not On Muscles

The muscle being the final executant of the act, a point needing elucidation is how far the administration of alcohol influences directly the functioning of the muscles themselves. The muscles differ sufficiently from the organs of the nervous system to make it probable that the influence of alcohol on the two will not be the same, at least, not of the same magnitude.

The influence of alcohol upon muscles separated from the nervous system has been exam-

ined, and it has been found that when administered to them through the blood in doses up to the equivalent of about 70 cubic centimetres in man or nearly 5 oz. of whisky at proof strength,* alcohol produces no obvious effect upon the contractile power or other functional properties of muscle.

We may infer then that any influence which alcohol, in such doses as are met with in ordinary human consumption of it, exerts upon the performance of muscular acts, must be referred to its effects upon the nerve centres concerned with activating the muscle.

Reflex Acts and Volitional Acts

The nervous processes which find their expression in muscular acts, are divisible into two main kinds. Those of one kind are termed volitional, because produced at the behest of the will; of the other, involuntary, because independent of the will. The former, even at their simplest, are complex. The latter, often spoken of as "reflexes," are less so. These latter are for this reason more completely understood and analyzed; the nervous events involved in them are suf-

*V. Furth and C. Schwarz, *Pflüger's Archiv. f. d. ges. Physiologie*, Vol. 129, p. 525. 1909.

ficiently known to serve as standards by which the effect of alcohol upon certain fundamental processes of nervous activity can be gauged. The relative simplicity of the reflexes has made it possible for medical study to ascertain with exactitude what parts and elements of the nervous system are required for their performance and to judge from them whether those parts are working well or ill. Changes in them give fairly precise information as to the seat and manner of any improvement or impairment they may show. They are of importance further, since it is by means of the nervous centres which the reflex acts use that volitional nervous acts, initiated in the higher nervous centres, exercise their effect upon their executant muscles. Skilled movements of hand and arm, executed under the mandate of the will, demand for their performance the employment by the brain of those same lower centres which the reflexes of the limb employ and test. The brain centres bring the muscles into action through the lower reflex centres.

If for some part of the body, say leg or eye, these latter are deranged, it is not to be expected that the skilled execution, by that part, of acts under the behest of the will can continue to be perfect or normal.

Influence of Alcohol on Simple Reflex Action

1. The Knee-jerk

A simple reflex act, much used by the physician for testing the healthy working condition of the spinal cord, is the knee-jerk. A light tap is dealt to the front of the knee just below the knee-cap, on the tendon of the muscle that straightens the knee. The tap is delivered at a time when the limb is at rest, for instance when one knee is passively resting crossed upon the other. This light blow stretches slightly and briefly the muscle, and this slight stretch excites nerve-fibres which pass from the muscle to the nerve-centres in the spinal cord, and so excites these centres. The centres in their turn excite the muscle by means of the motor nerve passing from them to it. This causes the jerk-like movement of the knee. This reaction test therefore, (1) the nerves passing from the muscle to the spinal centres and from the latter to the muscle; (2) the spinal centres themselves; and (3) the muscle. It gives reliable indications not only of the healthy or disordered condition of these parts, but in several respects also of the condition of the brain itself as influencing that of the spinal cord. The indications it yields are the more val-

uable because it is a reflex which lies beyond the voluntary control of the person examined. It cannot be quickened or slowed, increased or diminished at will by the person experimented on.

Experiments conducted by Dodge and Benedict* showed that a dose of 30 cubic centimetres of alcohol, equivalent to a little over 2 oz. of whisky at proof, or to about 1¼ pint of beer of average strength (i. e., containing 4 per cent of absolute alcohol), administered an hour to an hour and a half earlier, lessened the speed and amplitude of the movement of the knee-jerk in healthy persons. As an average obtained from observations on six men, this dose of alcohol reduced the speed of commencement of the responsive movement by 9.6 per cent and diminished the extent of the movement by 48.9 per cent. A larger dose, 45 cubic centimetres of alcohol, in the same persons impaired the reaction speed and amplitude still more.

These experiments were repeated by Miles†. He also found that the speed of the knee-jerk was lessened during the first 2¼ hours after a

*Dodge & Benedict: "Psychological Effects of Alcohol," Washington, 1915.

†W. R. Miles: "Effect of Alcohol on Psycho-physiological Functions." Carnegie Institute of Washington, 1918.

dose of 30 c. c. of alcohol. Subsequently the speed was somewhat increased. The effect of alcohol on the amplitude of the movement was irregular.

2. The "Eye-Closing Reflex"

Another reflex, somewhat less simple, is the "eye-closing reflex." The movement is an involuntary blink which occurs when some local danger imperils the eye, as when grit enters it or a blow threatens it. It commonly occurs also when some startling shock is received by the body, or when a loud, sudden, unexpected noise is heard. Although it is an involuntary act, repression of it can by practice and training be acquired in regard to circumstances which otherwise regularly evoke it. Thus, as a response to a threatened blow or to a sudden loud noise, those who are practiced in boxing and in the use of firearms learn to suppress it.

The effect of alcohol on this reflex has been examined by Dodge and Benedict* in the six normal men whose knee-jerk was tested as above. The dose of 30 cubic centimetres of alcohol retarded the reflex speed by 5.9 per cent., taking

*Dodge & Benedict, *op. cit.*, 1915.

the average from four of the men; it decreased the eyelid movement's extent by 10.7 per cent., taking the average measure from five of the men. Forty-five cubic centimetres of alcohol, equivalent to about 3 oz. of whisky at proof, or to nearly 2 pints of beer, impaired the reflex still more. In two of the men the smaller dose slightly increased the reflex-speed, and in one of these two the larger dose also increased it. The means used in these observations for evoking the eye-blink reflex was the sudden production of a loud noise. Both of the men in whom the dose of alcohol induced increase in the speed of the reflex were found normally and apart from any dosage with alcohol to exhibit unusually small blink-reflexes. The observers concluded that the normal blink-reflex in these two men was a partially restrained one, some degree of inhibitory control over the reflex having been acquired by them. One of them was practiced in boxing and one in revolver shooting. The observers concluded that the quickening of the reflex produced in these two cases by the alcohol was due to the alcohol weakening the acquired inhibitory control.

Miles found that 40 minutes after a dose of 30 c. c. of alcohol the speed of the movement was

decreased by more than 12 per cent. on an average. The speed gradually increased till 2¼ hours after the dose it was somewhat greater than normal; it then again became less. The extent of the eyelid's movement followed the same course as the speed.

Depressant Effect of Alcohol on Simple Reflexes

This dose of alcohol, therefore, depresses these simple reflex reactions of the nervous system. Even in regard to the somewhat greater frequency of the pulse-rate which commonly follows the administration of a moderate dose of alcohol, the cause seems to lie in a depressant rather than a stimulant action of the drug. The acceleration of the pulse appears to be due to depression in degree of the reflex cardio-inhibitory tone which normally restrains the heart beat*. The depression caused by the alcohol in all these instances indicates a specific lowering of the powers of the lower nervous centres, of a nature resembling, though much less in intensity, that produced by chloroform and drugs of that kind, tending towards temporary paralysis.

*Dodge & Benedict, *op. cit.*, 1915.

Difficulty of Analyzing Effect of Alcohol on Volitional Acts

Simple reflexes like the above form a suitable starting point for inquiry into any influence which alcohol may exert upon the nervous system in its performance of muscular acts. But the step from such simple reflexes to acts initiated and controlled by the will is a considerable one into a region of greater complexity. Besides the lower reflex centres through which the volitional processes must ultimately play, the nerve-centres concerned in calling forth and directing a muscular act at behest of the will are many, some in the highest parts of the brain and others in the lower, and some in the spinal cord itself. It is impossible to track the influence of alcohol step by step through such a maze. But it can be said with certainty that the degree of action of the alcohol will not appear equally in all the centres nor in all the phases of their processes. The detailed nature of the normal interaction of the various centres, whence the willed muscular act results is far from being as yet sufficently known to justify here an attempt to analyze the influence of alcohol on the separate steps of the process.

Effect of Alcohol on Efficiency of Willed Movements

Experiments have, however, been made which, without attempting to analyze the willed act, and accepting the movement made as index of its success, indicate how its efficiency changes with varying conditions. Three main directions in which the efficiency may vary are (1) in power, (2) in ability to withstand fatigue, and (3) in nicety of adjustment for the object in view. The power of a muscular act and its ability to withstand fatigue can be examined by the ergograph. This instrument registers the strength and extent of a particular willed movement which can be easily repeated, the instrument continuing its register throughout a series of repetitions of the act. The movement arranged for is purposely kept a very simple one, and therefore little scope is given in the ergograph for examination of nicety of adjustment, or other factors which constitute "skill."

Ergographic Experiments on the Effect of Alcohol

The influence of alcohol has been examined ergographically by many observers. Some of the observations appear, however, to be of small

value for our purpose; in some the dose of alcohol is unstated; in some the form of ergograph was unsatisfactory; in some too little heed was paid to circumstances, other than the giving of alcohol, likely to influence the muscular act under the conditions of the experiment. The earlier observers, impressed with the simplicity of the actual movement employed as an index, did not appreciate fully the extent to which mental conditions might affect it. Experience with ergographic records has shown that fleeting states of the mind, greater or lesser concentration of attention or greater or lesser interest in the repetition of the movement at one time than at another, may influence quite distinctly a person's performance of a movement even so simple as that chosen for the ergograph. Mental "suggestion" has to be excluded so far as possible from disturbing the subject's attitude toward the experiment, which should be a neutral attitude. The mere knowing that he has or has not received a dose of alcohol may affect his performance under the test and obscure or confuse any effect produced by the alcohol itself.

The researches in which precautions have been taken definitely to safeguard against these various sources of error are still relatively few, and

notable among them is the investigation by Rivers*. Rivers found that single doses of 5, of 10, and of 20 cubic centimetres of alcohol left no indubitable trace upon the muscular act, as recorded by the ergograph. His experiments were carried out upon two persons. When the dose was increased to 40 cubic centimetres, corresponding to over 2¾ oz. of whisky, or to about 1¾ pint of beer, an effect was produced on one of these. That person was habitually an abstainer from alcohol. The effect produced on his ergograph record was an increase in the series of contractions performed, this increase appearing about an hour and a half after the administration of the dose. The increase was small. On the other person examined the dose of 40 c. c. was followed by slight decrease of the ergographic work, but Rivers was not satisfied that in the case of this person the dose produced any clearly indubitable effect.

The result stands in general conformity with results obtained previously by Oseretzkowsky and Kraepelin,† who found no obvious evidence

*Rivers: "Influence of Alcohol and Other Drugs on Fatigue." London. 1907.

†Oseretzkowsky u. Kraepelin: in *Psychologische Arbeiten*, Vol. 3, pt. 4, p. 587: 1901.

of an effect of alcohol on the ergographic record after administration of a single dose of 50 cubic centimetres (i. e., 3½ oz. of whisky or a little over 2 pints of beer).

In the extensive series of ergographic experiments by Hellsten,‡ the ergograph employed was of an unusual type, the movement registered being executed with both arms, and therefore not so limited and simple as is generally preferred for ergographic examination. Working with this type of ergograph Hellsten tested the influence of alcohol upon its records. The subject of experiment was an athlete of 90 kilos [about 198 lbs.] weight. Single doses of 25 and of 50 cubic centimetres of alcohol, given in appropriate dilution with water 5-10 minutes before the ergographic record began, produced no close and unequivocal effect on the record. When the dose was 80 cubic centimetres, corresponding to between 5 and 6 ounces of whisky, or more than 3 pints of beer, there ensued, after a slight and brief-lasting improvement in the record, a marked decrease in the recorded muscular work. When this dose preceded the test by half an hour, the decrease observed amounted to 20 per cent

‡Hellsten: *Skandinav. Archiv. f. Physiologie.* Vol. 16, p. 160 1904.

of the normal performance done without alcohol. The decrease was 17 per cent when the dose preceded the test by one hour, and was 11 per cent when it preceded the test by two hours.

Animal Experiments to Test Effect of Alcohol on Work

Comparable in some measure with the above experiments are those carried out by Chauveau,* who examined the influence of alcohol upon the output of work by a trained dog turning a treadmill. The dog had a measured and liberal daily ration of raw meat and cane-sugar. When one-third, namely, 84 grammes, of the daily sugar ration was replaced by 50 cubic centimetres of alcohol the output fell by about 22 per cent. Similar results were obtained whether the alternation of the rations followed weekly or monthly. The dog lost weight on the alcohol substitution ration and maintained its weight on the ration

132, pp. 65 and 110. 1901.

without alcohol. The actual weight of the dog is not stated, but the daily amount of alcohol taken by it in the substituted ration must have been equivalent to not less than 250 cubic centimetres alcohol for a man, or not much short of a

*Chauveau: *Comptes rendus de l'Académie des Sciences.* Vol. 132, pp. 65 and 110. 1901.

pint of whisky. Dogs are, however, less susceptible to alcohol than is man.

Observations on Effect of Alcohol on Efficiency in Hill-climbing

Comparable also to some extent with these observations on the dog are observations by Durig* upon man. Durig observed the effect of alcohol upon the muscular exercise involved in walking to the top of a hill. The ascent and the route taken and the time of day and other conditions of the ascent were kept as far as practicable the same for a number of successive repetitions, with the exception that on some days 30 cubic centimetres alcohol in 150 cubic centimetres of water, i. e., as much alcohol as is contained in 2 oz. of whisky or 1¼ pint of beer, was taken in addition to the daily ration. This dose was taken at breakfast just before starting. It was found that although the walker, who was accustomed to moderate use of alcohol, felt in himself no difference between his condition on the alcohol and non-alcohol days, the distance and ascent per minute was on the alcohol days less by 12-14 per cent. than that on the non-alcohol days. This

*Dűrig. *Pflüger's Archiv für die ges. Physiologie.* Vol. 113, p. 314. 1906.

was so, although the expenditure of energy by his body was greater on the alcohol days than on the non-alcohol days. Durig inclined to attribute this deterioration in the performance of the ascent to impairment of skill with which movements are directed. He says that it was as if the effect of previous training in the act were temporarily lost. The experienced climber is reduced by the dose of alcohol towards the level of a beginner at such work and makes an unduly large number of badly directed or ill-judged movements. In short, alcohol in a dose of 30 c. c. tended to undo the effect of previous training. The act here was of course much more complex and gave much more scope for skill than the acts examined by the ordinary ergograph.

Disturbing Effect of Alcohol on Skilled Movements

Rivers, in an appendix to the account of his ergographic observations, notes that, although the ergographic records showed, even when the dose of alcohol was 40 cubic centimetres, slight evidence only of their being influenced by it, there was from the experiments other evidence to the effect that after that dose "the control of movement did not appear to be so good," and

that the execution of movements tended to be slower than usual. His evidence for this is as follows: "In the normal condition," i. e., of the subject experimented upon, "the two minutes allowed him between successive ergograms for taking the customary readings and for making necessary adjustments of the ergograph were ample for his doing so; but on the 40 c. c. alcohol days the period of two minutes was hardly long enough for him to do what was necessary, although the time it took him seemed to him no longer than usual. This was so striking that the subject was at first inclined to believe that his watch was in error, for it seemed to him that he had been carrying out his usual task at the normal speed."

"Several small accidents happened on days on which the dose of alcohol was 40 c. c., and these were probably the result of awkwardness in adjusting the apparatus. Some of the intervals" (between the actual spells of exercise at the ergograph) "were occupied" (by the subject) "in drawing lines for tabular purposes or in pasting ergograms in a book, and these operations were found afterwards to have been done roughly or irregularly on the 40 c. c. alcohol days."

Experiments designed for the special purpose

of testing the effects of alcohol on the accurate co-ordination of nervous and muscular activity which is necessary for skilled movements have been carried out by Vernon* and by McDougall and Smith†.

McDougall and Smith studied the effects of alcohol on persons in a normal condition and when unduly fatigued by enforced lack of sleep. They employed the "dotting machine" and a simple memory test. The dotting machine is an apparatus by which a paper tape about one inch wide is made to pass before the subject by clock work. The subject sees at any moment only as much of the tape as appears behind a small window in the top of the machine. On the tape is printed an irregular line of small red circles and the subject attempts to make a dot in each circle as it passes the window.

The results showed that more mistakes were invariably made after a sufficient dose of alcohol had been taken. The dose might be as small as 10 c. c. if taken some hours after a meal, though 30 c. c. taken with a meal had only a very slight action. The result of diluting the dose was also to decrease its effect.

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*Medical Research Committee, Special Report No. 34, 1919.
†Medical Research Committee, Special Report No. 56, 1920.

The action of alcohol was the same both in the normal and fatigued condition of the subject, except during a period which can best be described as one of convalescence following much loss of sleep; during this period, alcohol had the effect of improving the results of the test.

Vernon used as tests (1) the speed and accuracy with which a short paragraph, which the subject knew by heart, could be reproduced on the typewriter; (2) quickness and accuracy in using an adding machine; (3) the "target" test. In the latter, the subject is required to prick a hole as near as possible to each of a series of dots in a piece of paper, the paper being fixed in a vertical position, at arm's length from the subject.

He found in all his subjects and with all the tests employed that the accuracy of the muscular movements was impaired after alcohol had been taken. The effects varied according to the susceptibility of the subject, the amount taken, and the conditions under which it was taken. It was found to have less effect when taken diluted or with food.

Unfortunately a large proportion of Dr. Vernon's experiments are, from the point of view of the psychologist, open to the objection that the

observer and the subject were one and the same person, who, in carrying out tests involving volition and skill, knew what amount of alcohol had been taken, and was aware of the suggested influence of relation to meals, dilution, etc. The results are therefore not so convincing as they otherwise might have been, and it can only be said that they show no disharmony with those obtained under more suitably controlled conditions.

Miles* employed a somewhat elaborate electrical apparatus, "the pursuit-meter." The task set the subject was analogous to that of a sailor steering a ship on a given course by compass. He has to manipulate the wheel in such a way that a certain point on the circumference of the compass card is always exactly opposite another point on the fixed framework of the compass. If the ship moves from her course, under the influence of the wind or waves, the compass card will begin to swing in one or other direction, and must be brought back by the correct movement of the wheel. The needle of the pursuit-meter, which the subject must keep steady in an analogous manner, receives impulses to swing in one or other direction in a much quicker and more

*W. R. Miles; *J. Exper. Psychol.* Vol. 4, p. 77, 1921.

irregular manner than does the compass card in a ship, and the subject has to counteract these impulses by corresponding movements of a handle. When the needle deviates from the proper position, it allows an amount of current proportional to the extent and duration of the deviation to pass through an electric meter which records the number of units passing; so that the more accurate the movements of the subjects are, the less the meter will record.

Miles found the amount of current allowed to pass by his subject after he had drunk a litre of 2.75 per cent alcohol (approximately equivalent to 1½ pints of very light beer) was on an average about 11 per cent., more than when he had drunk the same quantity of water.

Effect of Alcohol on Adjustment of Eye-Movements

The evidence summarized in the preceding section shows that the execution of skilled movements tends to be impaired by alcohol.

This stands in harmony with observations by Guillery* on the influence of alcohol on certain movements of the eye. Guillery tested the

*Guillery. *Pflüger's Archiv für die ges. Physiologie.* Vol. 79, p. 597. 1899.

ability of the eyes to follow clearly an object brought nearer and nearer to the person observing it, that is to keep both eyes focussed on it as it approached. This requires a convergent movement of the eyeballs, the convergence increasing in degree as the object is brought closer. At a certain closeness further convergence becomes impossible and fixation is lost, the object no longer appearing single. He found that the degree of convergence possible for the person was not affected, either in the direction of improvement or impairment, by a dose of 20 cubic centimetres alcohol, equivalent to nearly 1½ oz. of whisky, or to over three-fourths of a pint of beer, but that by a dose of 40 cubic centimetres it was very distinctly impaired. The impairment took the form of weakening and of slowing of the movement. The impairment was first detectible about 20 minutes after the taking of the dose; normal speed and power were regained about 40 minutes later. With 60 cubic centimetres of alcohol the impairment was greater, came on about 10-15 minutes after the dose and lasted for an hour and a half. The opposite movement of "divergence" was impaired even more, and other eye movements similarly examined were found also to be impaired. Guillery

remarked that at no stage of the action of any dose of alcohol were the eyeball movements found to be strengthened or rendered quicker.

Similarly, Dodge and Benedict found that a dose of 45 cubic centimetres of alcohol measurably impaired the speed of starting the movement of turning the eyes toward a fresh object; in short, the speed of directing the gaze. The whole movement is one of considerable complexity of nervous adjustment. The twelve muscles of the eyeballs have all of them to act appropriately together, that is to say, some have to be made to contract more than they were contracting, others have to be relaxed from contraction, and these changes have to be made in each muscle with harmonious rate and degree. To execute the movement the nerve centres must not only have perfect control of the necessary motor powers, but must be aware of the posture the eyeballs start from and of the direction toward which they have to be moved. These latter requisites demand the alertness of sensory nerve-centres, information from which is a factor in the guidance and alertness of the motor centres themselves.

The act is, of course, one of extremely frequent execution throughout the waking day, and

from an early period of infant life onward. It is, indeed, in many respects a reflex act; and it is under many circumstances impossible, and under still more very difficult, to repress it by the will; it tends to occur "in spite of ourselves." A form, however, in which we meet its use in a highly practiced technical act is that trained movement, learned in reading, which enables the eyes to follow the words across a page and then return correctly to the first word in the line immediately below. As with all other acts of the kind, a slight delay attends its starting, a delay which though it is not long is yet considerably longer than the delay attending such simpler reflexes as the knee-jerk. The influence of alcohol on this delay has been tested and on the same persons as those forming the subjects of the experiments on the simpler reflexes.

A dose of 45 cubic centimetres alcohol was found, an hour and a half after it had been taken, to increase the delay (average of all six men) by 15 per cent. The accuracy of the movement, that is, the degree of truth with which the eyeballs when moved hit the required direction, was not tested.

Similar experiments were carried out by Miles, who gave his subject a dose of 30 c. c. of alcohol.

He found that the speed of the movement was decreased by 13 per cent, 1½ hours after the dose was taken, and remained less than normal for a further 1¾ hours. Miles also examined the effects of alcohol on the speed of eye movements in another manner. The subject was required to look first at one fixed point, then as quickly as possible to move his eye on to another point, then back to the first, making as many movements as possible in five seconds. The effect of a dose of 30 c. c. of alcohol was to diminish the total distance moved by the eye by 21 per cent. on an average.

Effect of Alcohol on Speed of To and Fro Movement of Finger

Dodge and Benedict designed an experiment testing the performance of an act relatively simple in character yet one which is not naturally regularly practiced, namely, a rapid to and fro movement of a finger, the person being told to move the finger thus as rapidly as possible. The index of success taken was the speed with which the movement could be alternated, the rate at which the to and fro movements could be made to follow each other. While requiring the action of relatively lower nervous centres the exer-

cise demands therefore in addition some effort of the higher centres in controlling and urging the former. It involves activity of the will and, though not to a high degree, demands that kind of effort which is necessary for acquiring facility in a novel manoeuvre which habituation has not as yet made easy. It is, therefore, to this extent a test of skill, skill taking effect in speed. It tests, though very simply, just that type of nervous process which is involved in the first steps of learning to use a new tool or attaining dexterity in a new manual process.

The effect of alcohol as thus tested was examined in the same six men employed for the "turning of the gaze" test. The dose of 45 cubic centimetres of alcohol taken an hour and a half previously reduced the rapidity with which the movement could be performed by 8.8 per cent. (average of the six persons).

Confirmatory results were obtained by Miles, who found that a dose of 30 c. c. of alcohol slowed the finger movements by 3 or 4 per cent.

Effect of Alcohol on Memory

McDougall and Smith, in addition to the experiments referred to above, submitted the same subjects to the following memory test. A list of

forty words was read to the subject, who was afterwards required to reproduce them in the correct sequence; each word was related to the previous word by its actual meaning, or by an alternative meaning suggested by its sound, which the subject could grasp by an act of attention, e. g., mountain, plain, ugly, beauty, Venus, Greece, oil, smooth. . . .

The results agreed with those obtained with the dotting machine in that more mistakes were made after alcohol had been taken, except during the period in which the subject was recovering from fatigue.

Miles employed a memory test of a different kind. A series of twelve four-letter words, with no connection between the meanings of successive words, was pasted to a cylinder, hidden from the subject by a screen in which was an aperture large enough to expose one word. The cylinder was made to revolve in such a way that each word in the series was made visible to the subject in succession at intervals of four seconds, the last letter of the word appearing first. The subject was required to read each word out aloud as it appeared. The same series of words was then exposed a second time in the same way. During the second exposure the subject was required to

say each word aloud as soon as he could, either before it had started to appear or when as little as possible was showing. During both exposures an automatic record was made of the exact instant at which the subject started to say each word, and from this record could be deduced the time interval which separated the moment of complete visibility of each word and the saying of it by the subject. During the first exposure, the saying of the word followed its complete visibility and during the second, it preceded it. The sum of the two time intervals for each word was a measure of the time saved by the subject having remembered, or partly remembered, the word; and was used as one measure of memory. Another measure was obtained by employing only the record of the second exposure and measuring the time by which the saying of the word preceded its complete visibility. Both methods of measurment gave the same result: that the memory, as tested by the procedure described, was improved after 30 c. c. of alcohol had been taken.

There is thus an apparent contradiction between the conclusions of the authors quoted, but the contradiction is explained by the fact that different forms of mental activity were tested in

the two series of experiments. Whereas in McDougall and Smith's experiments each word was recalled to memory by the association of its meaning with that of the previous word in the list, in Miles' each word was recalled either because the subject remembered that it stood next to the word previously seen, or, if he had to wait till one or more letters of it appeared, by the remembered contiguity of the letter or letters so appearing to those not yet visible.

The former process is certainly on a higher intellectual plane than the latter, and as has been pointed out in the preceding chapter, the higher intellectual processes were probably the last to develop in the evolution of mind and are the first to be affected by alcohol.

Some Sensory Effects of Alcohol

McDougall and Smith tested the effects of alcohol with an aesthesiometer, which is an instrument designed to measure the accuracy with which tactile impressions can be localized or discriminated in different areas of the skin. It consists of a pair of compasses with blunt points, which are applied to the skin of the subject, who is then asked to say, without looking, whether he is being touched by one point or by two. The

more delicate the power of localizing sensations of touch, the more easy is it to feel the two points of the instrument as separate points. McDougall and Smith tested always the same skin area and kept the points of the instrument 2.5 cms. apart. They found that 4½ hours after a meal the average percentage of errors before taking alcohol was 24, and after taking alcohol, 90. When, however, the test was done immediately after a meal, the effect of taking alcohol was much less, the percentage rising from 18 to 27 only. Miles determined the "threshold of faradic stimulation," that is to say, the smallest electric shock applied to the skin which could be felt, and found that after alcohol had been taken, the strength of the electric current had to be increased before the shock could be felt.

Subjective Effects of Alcohol

Rivers records with regard to the subject of his ergographic experiments—

"Within half an hour of the taking of the 40 c. c. alcohol there came on," in this person, "a subjective feeling of lassitude and disinclination for activity either of body or mind." "It was doubtful how far the state of lassitude was preceded by one of exhilaration, but, if the latter

occurred, it was certainly of very brief duration." "During the state of lassitude there was decided irritability; and a fellow worker states that he was able to recognize clearly the days on which the 40 c. c. dose had been taken by the general demeanor of the subject—partly from his lassitude, partly from his very obvious irritability."

McDougall and Smith note that, after taking alcohol, their subjects felt dizzy and heavy and had difficulty in beginning any task, but on the other hand felt when doing the "dotting machine" test that they were doing it well and that the "words" in the memory test were easy. These flattering impressions were, however, not confirmed by the results of the tests, which, as shown above, were worse than normal.

Conclusions

It will be seen that experiments suitable for yielding inferences for the present purpose are not numerous; and that, for that reason alone, caution is necessary in making deductions from them. Yet, they agree in indicating that a single dose of less than 40 cubic centimetres of alcohol, or as much as would be taken in about 2¾ oz. of whisky at proof, or in 1¾ pints of beer, in an adult accustomed to moderate use of

alcohol, exerts little or no appreciable influence on the performance by him of a muscular act of simple character not demanding precision. For acts requiring skill the inference from the experiments, so far as they go, seems, however, to be that their performance tends to be temporarily impaired after a dose of alcohol of even less than 40 cubic centimetres, e. g., 30 cubic centimetres; especially in the diminished speed and nicety of the required act's performance. It seems, therefore, permissible to suppose that the greater the precisional delicacy and alertness demanded in a muscular act and the greater its degree of difficulty, e. g., by reason of novelty to the performer, the more liable will that act be to show impairment under the influence of alcohol, and, within limits, the smaller will be the dose of alcohol which may impair the act. Reliable evidence that alcohol improves, in normal circumstances, the efficient performance of any muscular act, unskilled or skilled, seems at present to be altogether lacking.

Similarly the evidence points to the depression by alcohol, in any doses in which it affects them at all, of mental processes, if they involve in any degree the higher mental faculties. On the

other hand there is evidence that the rapidity with which a simple memory, such as that of a word once seen, is recalled to consciousness may be increased by alcohol in moderate doses.

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