STUDIES ON THE PSYCHOPHYSIOLOGY OF BOREDOM: PART I. THE EFFECT OF 15 MGS. OF BENZEDRINE SULFATE AND 60 MGS. OF EPHEDRINE HYDROCHLORIDE ON BLOOD PRESSURE, REPORT OF BOREDOM, AND OTHER FACTORS [1, 2]

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A theory of McDowall and Wells (4) that the feeling of monotony may be due to an inadequacy of blood circulation for the work being performed, stimulated two researches by the present investigator.

In one of these (1), an attempt was made to find the interrelationships between oxygen consumption, blood pressure, heart rate, subjective ratings (particularly the ratings on a scale of bored-interested), and work output on two tasks expected to be boring, and one task expected to be interesting. Among the results reported in this study, one is of particular relevance to the present investigation. It was found that while physiological changes were closely related to changes in output and feeling tone in a few individual cases, for most subjects this relationship was not sufficiently close to warrant support of the hypothesis of McDowall and Wells that certain peripheral vascular inadequacies are essential to the feeling of monotony. Instead, it was suggested that the feeling of monotony is a result of the operation of more general factors such as the tendency of the subject to revert to a sleep, or sleep-like state during the operation of a task-set. Psychologically interpreted, the cause of this reversion appeared to

[1] The study was performed under the medical supervision of Dr. W. H. McCastline, Columbia University Medical Officer, and members of his staff, to whom I am deeply indebted for their assistance.

[2] I wish to express my gratitude to Dr. A. T. Poffenberger, of Columbia University, whose very generous aid made this study possible.

be the restriction of attention to an inadequately motivated task. The effects of this inadequate motivation become manifest when the dynamic influence of the novelty of the task wears off.

In a second study by the present investigator (**2**), an attempt was made to check on the correctness of an analysis of boredom outlined in the first study. Boredom was described as a state of conflict between the tendency to continue and the tendency to get away from a situation which has become unpleasant principally because of inadequate adjustments to it, resulting from inadequate motivation. The adjustments include all those factors which vary with the sleep-alertness continuum. If the analysis is correct, making the task more strongly motivated, or counteracting the hypnotic trend during 'boring work,' should interfere with the development of a bored attitude to the task. In this second study on 36 subjects, it was found that 10 mgs. of the antihypnotic, benzedrine sulfate, retarded the development of an unfavorable attitude to the task of adding pairs of six-place numbers. In the present investigation, we were interested in finding whether the effects of benzedrine sulfate on the work attitude could be duplicated with another type of repetitive task, such as pursuit-meter operation, and whether other antihypnotics such as 60 mgs. of ephedrine hydrochloride, or a drop in room temperature, or an added financial incentive, would be similarly effective.

The aims of the current investigations, therefore, were to study the possible effects of 15 mgs. of benzedrine sulfate, 60 mgs. of ephedrine hydrochloride, a drop of approximately 10 degrees C. in room temperature, and a financial incentive, on accuracy during two hours of pursuit work, on blood pressure objectively recorded, and on subjective reports on six nine-point scales, of bored-interested, relaxed-strained, irritated-pleased, peppy-fatigued, sleepy-wide awake, attentive-inattentive.

In this paper the effects of 15 mgs. of Benzedrine and 60 mgs. of ephedrine hydrochloride on the above mentioned variables are presented. The effects of the other two factors are reported in the subsequent paper.

Subjects

Ten male graduate students at Columbia University participated in this experiment. Six of them were paid directly for acting as subjects. Four of the ten were remunerated through the N. Y. A. The age range was from 21 to 24.

Procedure

The subjects were first given medical examinations by the medical staff of Columbia University to determine whether they were physically fit for the experiment. Then, to acclimate them to the apparatus and get low resting measures, they visited the Applied Psychology Laboratory at Columbia University for a *preliminary series* of at least nine half-hour sessions. Throughout the entire experiment, the subjects were instructed to have their last meal at least three hours before coming to the laboratory. In the first four of these half-hour sessions, the resting blood pressure and heart rate were recorded three times at ten-minute intervals by means of the Tycos recording sphygmomanometer. During the next four sessions, the three measures during rest were obtained again. A fourth measure was added one minute after the instructions were given to pull on a forty-pound body ergometer fifty times.[3] Following this fourth measurement, the subject did the work. In the ninth and last of this preliminary series, the subjects were given specific instructions on the operation of the pursuitmeter, which was the main task, and went through a short trial period of pursuitmeter work. At the beginning of every main experimental session, the subjects were given a gelatin capsule of a uniform size, color and shape. The capsule contained either 15 mgs. of Benzedrine, 60 mgs. of ephedrine hydrochloride, or placebo. The order of the compounds used was consistent with a prearranged schedule. The order for the control with placebo, cold room with placebo, ephedrine hydrochloride, and Benzedrine, was such for each subject that no condition had a position of advantage. The incentive condition was always last, for special reasons.[4]

After the subject had swallowed the capsule, the sphygmomanometer cuff was adjusted to the non-preferred arm, and the subject was seated in a soft, leather armchair, in front of the Poffenberger pursuitmeter.[5] Final instructions were given to the subject to remain quiet during the half-hour rest period to follow, to fill out the subjective rating sheets accurately at a light-signal, and to work on the pursuitmeter as accurately as possible. The subjective rating sheets were similar to the one reported in a previous study (2) except that the individual scales on them were shifted in successive sheets to minimize a stereotypy of response. Blood pressure was recorded with the Tycos recording sphygmomanometer. The heart rate was determined by

[3] The purpose of the latter procedure was to find the effect of such an 'aufgabe' on the resting physiology. The results of this experiment will be incorporated in another paper.

[4] Mainly to avoid a possible carry-over of the effects of the incentive to the subsequent conditions.

[5] Essentially, the Poffenberger pursuitmeter consists of a table, on the top and in the central and distal end of which are two pointer arms. The standard which points down is moved irregularly back and forth by a motor and eccentric pulley arrangement. The variable which points up is to be aligned with the standard pointer. By means of a brush and commutator-like device attached to the pointer arms and a battery of electrical counters, a record is obtainable of the displacements of the variable from the standard.

clocking 25 pulsations. The obtained figure was interpolated to read beats per minute. The procedure for each of the main experiments (except the incentive experiment) from this point was as follows:

1. During the half-hour rest period, blood pressure and heart rate were each measured three times at ten-minute intervals. These measurements were made behind a one-way light screen.

2. At the end of the third measurement, the subject was signalled, whereupon he filled out the first subjective rating sheet, turned it over face down, and, without any further instructions, immediately began to operate the pursuitmeter for an accurately timed fifteen-minute interval.

3. During the fifteen-minute work period, and without stopping the work, vascular measures were taken twice, the first after five minutes, and the second after ten minutes of work. The two readings were averaged.

4. At the end of the fifteen-minute period, the subject was signalled, he stopped the pursuit work and filled out the next subjective rating sheet while the experimenter recorded the pursuit performance for that period. As soon as the subject finished filling out the rating sheet, he was signalled again to resume the pursuit work.

5. The entire process was repeated until the subject had completed the eight fifteen-minute periods of work of the particular session.

We experienced difficulty in pegging accurately the diastolic pressure with the Tycos recording sphygmomanometer. For this reason, the measure is not regarded as reliable, and is neglected in the discussion of the results.

Results

The essential data are presented in Fig. 1. In determining the reliability of the obtained mean differences, Fisher's method (3) for testing the significance of the differences of the means of small samples was used. For each variable studied, 8 or 9 sets of measures are presented for each two and one-half hour experimental session. In view of the fact that the measures shift in any one experimental session, an average of all the measures of a single variable for a given session would be meaningless. For this reason, in discussing the reliability of the differences between the means of, for example, Benzedrine and placebo systolic pressures, reference is made to the means at representative or meaningful periods of the two-hour work session. Although each of these mean differences may not satisfy Fisher's criterion of significance, certain consistent differences may be considered as significant. It is intrinsic to the form in which the data appear that the significance or lack of significance in some cases becomes a function of the judgment of the interpreter. Duplicate measures on a single subject which tend in the same direction are of

value in minimizing the role of chance as a factor in their interpretation. However, they do not affect the role of chance in the selection of subjects. Therefore, to permit the reader to evaluate the significance of the data, Fisher's p values (chances in 100 that so large a difference between the two means is due to chance) are presented for differences at key

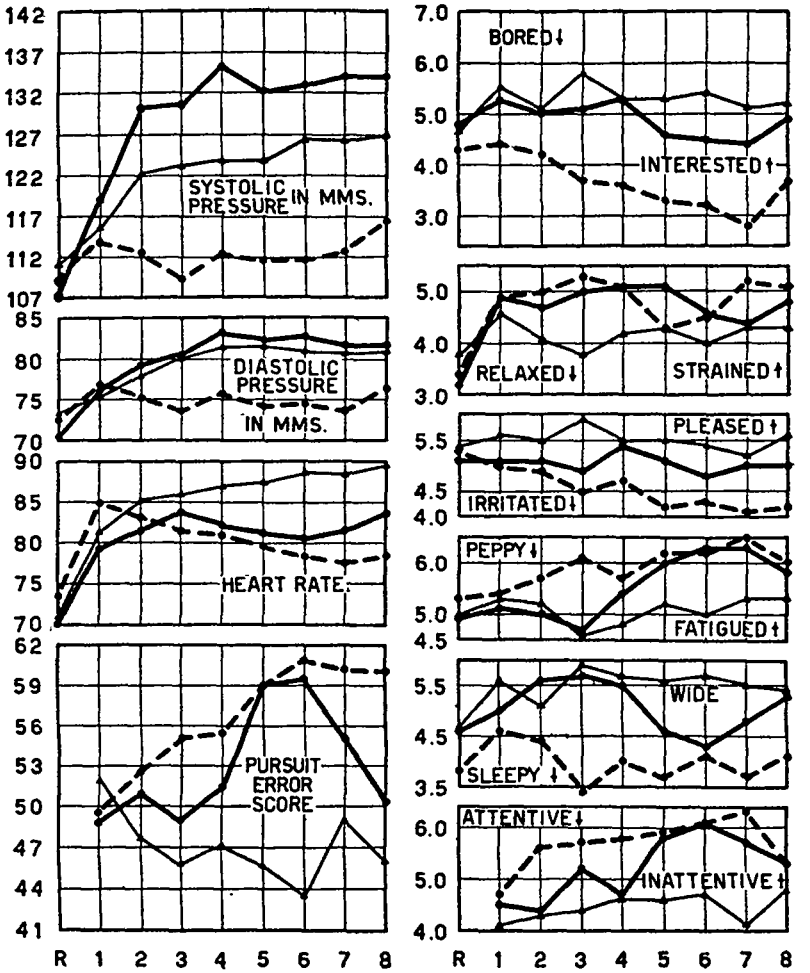

FIG. 1. The thin continuous line represents the Benzedrine condition. The heavy continuous line represents the ephedrine conditions. The broken line represents the placebo condition. *R* represents a thirty-minute rest period. 1, 2, 3, etc., represent successive 15-minute pursuit activity periods. Arrows indicate the direction of increase on the subjective rating scales.

periods. Where the p value is *less* than 1, t[6] values are presented.

A. The Effects of 15 mgs. of Benzedrine Sulfate on the Factors Studied

1. *Systolic Pressure.*—The Benzedrine administered in a gelatin capsule achieves its optimal effect on systolic blood pressure within approximately one hour. The differences in systolic pressure between the Benzedrine and control conditions for the remaining work periods are of the order of 12 mms of mercury. The t values for these differences are at the third period, 3.3, at the seventh period, 4.5, and at the eighth period, 3.5. The pressor effect of the 15 mgs. of Benzedrine is clearly indicated by the data under the conditions of the experiment.

2. *Heart Rate.*—The mean differences in heart rate between the Benzedrine and control conditions are of the order of five beats per minute, one hour after the administration of the capsule. The t value for the difference of the means at the seventh period is 4.4, and at the eighth period, 5.1. Under the conditions of the experiment, the cardioaccelerating effect of the 15 mgs. of Benzedrine is also clearly demonstrated.

3. *Pursuit Error Score.*—Under the influence of the 15 mgs. of Benzedrine, pursuit accuracy increases slightly, whereas with the placebo, the performance become progressively inaccurate. The p value for the difference between the two mean error scores at the sixth period is 8, at the seventh period, 27, and at the eighth period, 11. While these values are too high to regard the differences at individual periods as significant, there are reasons for so regarding the differences of a series of periods. Firstly, the trend of the differences is one of increasing dispersion. Secondly, the *critical ratio* for the difference in error score between the averages for the Benzedrine and placebo of the sixth, seventh and eighth periods combined is 4.7. Thirdly, one subject, despite the Benzedrine, fell asleep for a good part of the seventh period,

[6] The t value corresponds to a critical ratio. For the number of degrees of freedom here available (9), when t equals 3.25 or better, the chances in 100 that so large a difference as the one obtained may be due to chance are 1 or less.

raising his error score from 65.4 in the sixth, to 104.1. This increase accounts for the unusually high p value reported for the error score difference at the seventh period. The foregoing reasons warrant the conclusion that under the conditions of the experiment, the 15 mgs. of Benzedrine arrested the development of pursuitmeter inaccuracy.

4. *Report of Boredom.*—The data demonstrate clearly that the 15 mgs. of Benzedrine prevented the development of that condition which would have resulted in a report of boredom. The p value for the mean difference in rating at the third period is 1.5; the t value at the seventh period is 3.8, and the p value at the eighth period is 3.

5. *Report of Strain.*—The effect of the Benzedrine on the report of relaxed-strained is not clearly indicated by the *trend* of the data. There is a suggestion, however, that the Benzedrine prevents the development of a feeling of strain under the conditions of the experiment. The p value for the mean difference in rating at the third period is 1.5, and at the eighth period, 19.0.

6. *Report of Irritation.*—The mean differences in the rating on the scale of irritated-pleased between the Benzedrine and placebo conditions suggest that the Benzedrine prevents the development of a feeling of irritation. The p value for the mean difference in rating at the third period is 1, at the seventh period, 7, and at the eighth period, 3.

7. *Report of Fatigue.*—The mean differences in ratings on the peppy-fatigued scale suggest that the Benzedrine prevented the development of a feeling of fatigue under the conditions of the experiment. The t value of the mean difference at the third period is 4.4. The p value of the mean difference at the seventh period is 6, and at the eighth period, 25.

8. *Report of Sleepiness.*—The antihypnotic effect of the 15 mgs. of Benzedrine is reflected in the mean differences in ratings on the sleepy-wide awake scale. The p values at the third, seventh, and eighth periods are 1, 2, and 8, respectively.

9. *Report of Attention.*—The data suggest that the subjects felt their attention to the task was better sustained under the Benzedrine than under the placebo condition. The p

values for the differences at the third, seventh, and eighth periods are 9, 1, and 40 respectively.

Summary on the Effects of the 15 mgs. of Benzedrine.—In many instances, statistical tests of the significance of differences between the measures of the Benzedrine and the control condition at specific periods are not satisfactorily met. Nevertheless, in the judgment of the writer, the trends of the repeated measures give the differences a high degree of reliability, with the exception of those obtained on the relaxed-strained scale. The data therefore permit the conclusion that the 15 mgs. of benzedrine sulfate increase the systolic blood pressure and heart rate, and prevent the development of a bored attitude to the repetitive pursuit task as manifested by sustained pursuitmeter accuracy and 'favorable' ratings on a series of subjective rating scales.

B. The Effects of 60 mgs. of Ephedrine Hydrochloride on the Factors Studied

1. *Systolic Pressure.*—The ephedrine hydrochloride had a marked pressor effect (see Fig. 1). The *t* values for the differences in mean pressure between the ephedrine and placebo conditions at the third, seventh, and eighth periods are 6.3, 6.1, and 3.6, respectively.

2. *Heart Rate.*—The effect of the drug on the heart rate under the conditions of the experiment is negligible.

3. *Pursuit Score.*—The effect of the ephedrine on pursuit accuracy is peculiar. Initially, the tendency is to sustain accuracy of performance; this tendency is followed by a sharp drop in accuracy in the fifth and sixth periods, and then by an improvement toward the end. This depression might be considered an artifact were it not for analogous changes indicated in most of the subjective ratings for the corresponding periods. The *p* value for the mean difference between the ephedrine and placebo pursuit scores at the third period is 25, and at the eighth period, 3. Nevertheless, the average pursuit error scores under ephedrine do not exceed those under the control condition. In sum, two results are of interest; first, the 60 mgs. of ephedrine hydrochloride tend to

sustain pursuit accuracy initially, and second, that one and one-half hours after its administration in capsule form, a depression in accuracy occurs for the duration of half an hour. That the depression is no artifact is indicated by certain parallel, subjective rating changes.

4. *Report of Boredom.*—The average ratings on the bored-interested scale under ephedrine hydrochloride follow closely those of the Benzedrine except in the fifth, sixth, and seventh periods, when the ephedrine appears to be slightly less effective. The p value for the mean difference between the ephedrine and control condition at the third period is 4, at the seventh period, 3, and at the eighth period, 8.

5. *Report of Strain.*—There are no consistent differences in the averages of the ratings on the relaxed-strained scale between the ephedrine and placebo conditions.

6. *Report of Irritation.*—The effect of the ephedrine on the reports of irritated-pleased is slight and consistent, but it is less than for the 15 mgs. of Benzedrine.

7. *Report of Fatigue.*—The changes in report on the peppy-fatigue scale under ephedrine are of interest. The maximum stimulating effect of ephedrine is reached in the third period where the p value of the mean difference between the ephedrine and control conditions is 2. Thereafter the effect on this scale is negligible.

8. *Report of Sleepiness.*—The effect of the ephedrine on the report of alertness is similar to that on the peppy-fatigued scale. The maximum effect is reached in the third period. The t value for the difference between the ephedrine and placebo averages at that period is 3.4. The reports shift to sleepiness in the fifth and sixth periods. A rise towards alertness occurs in the seventh and eighth periods. The p values for the mean differences at the seventh and eighth periods are 5 and 4 respectively.

9. *Report of Attention.*—The effect of the ephedrine on the report on the attentive-inattentive scale is manifest only in the early part of the work session. The p values for the mean differences at the second, third, and fourth periods are 5, 50 and 8, respectively.

In sum, under the conditions of the experiment, the 60 mgs. of ephedrine hydrochloride have a marked stimulating effect on the systolic pressure but a negligible effect on the heart rate. The pursuitmeter and subjective rating data *suggest* that initially the ephedrine retards the development of an unfavorable attitude to the repetitive pursuit work. However, approximately one and one-half hours after the administration of the drug, an alteration occurs in this tendency, giving rise to a relative depression in pursuit accuracy and most subjective reports. A recovery in the last half-hour follows the depression, according to some of the indices used. No systolic blood pressure or heart rate changes parallel the obtained depression. Here again, as with the Benzedrine, statistical tests for the significance of mean differences at individual periods are not satisfactorily met in many instances. But, in the judgment of the investigator, the data assume significance by their internal consistency.

C. A Comparison of the Effects of 15 mgs. of Benzedrine and 60 mgs. of Ephedrine Hydrochloride

1. *Vascular Effects.*—The 60 mgs. of ephedrine hydrochloride have a superior pressor effect than the 15 mgs. of banzedrine sulfate. However, the 15 mgs. of Benzedrine are more effective in accelerating the heart rate.

2. *Pursuit Performance and Subjective Ratings.*—A comparison of the two drugs with regard to pursuit accuracy and subjective ratings is made difficult by the peculiar alteration which occurs in the effects of the 60 mgs. of ephedrine hydrochloride approximately one and one-half hours after its administration. One definite conclusion is permitted, however. The 60 mgs. of ephedrine hydrochloride is not *more* effective, but is, if anything, *less* effective than the 15 mgs. of Benzedrine in counteracting the monotonous influence of the task.

Discussion

The results of the present investigation on the effects of 15 mgs. of Benzedrine confirm a previous finding (2) with 10 mgs. of the same compound, that it retards the development of an unfavorable attitude to a repetitive task.

The course of some of the effects of the 60 mgs. of ephedrine is peculiar. Approximately one hour after its administration, the ephedrine influences pursuit accuracy and subjective ratings almost as effectively as the 15 mgs. of Benzedrine. The stimulation lasts for approximately one-half hour, but thereafter a depression in pursuit accuracy and in 'feeling tone' occurs which has no counterpart in the vascular measures used. There is an uncertain indication according to some of the psychological measures that the stimulating influence of the ephedrine is restored in the succeeding half-hour of pursuit effort. This peculiar course of the effects of the ephedrine is of twofold significance. First, it demonstrates within a single session, the possible independent variation of 'feeling tone' and work output on the one hand, and systolic blood pressure and heart rate on the other. Secondly, it points to the necessity of studying the psychological effects of drugs for a continuous, long period just as their physiological effects are usually so studied. The fact that the physiological effects of a drug run a consistent course is no guarantee that the psychological effects will also be consistent.

Summary and Conclusions

The effects of 15 mgs. of benzedrine sulfate and 60 mgs. of ephedrine hydrochloride were compared with those of a control pill with regard to systolic blood pressure (objectively recorded), heart-rate, pursuitmeter accuracy, and subjective ratings on a nine-point scale of bored-interested, relaxed-strained, irritated-pleased, peppy-fatigued, sleepy-wide awake, and attentive-inattentive. Ten apparatus acclimated subjects participated in this experiment. The main findings under the conditions of the experiment are as follows:

1. The 15 mgs. of Benzedrine *retarded* the development of:

a. Pursuit inaccuracy,

b. A condition leading to a report of boredom, of irritation with the work, of fatigue, of sleepiness, and of inattention.

2. The 15 mgs. of Benzedrine increased the systolic blood pressure and the heart rate.

3. The 60 mgs. of ephedrine hydrochloride had a similar, though weaker and more transient, effect on pursuit accuracy and on the subjective ratings.

4. The 60 mgs. of ephedrine hydrochloride had a more pronounced effect on the systolic pressure than the 15 mgs. of Benzedrine, but was practically without effect on the heart rate.

5. A peculiar depression in the 'sustaining' effect of the ephedrine is obtained on most of the psychological measures used. This depression has no correlate in the systolic pressure or in the heart rate changes.

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