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THE EFFECT OF MOTIVATION ON OUTPUT IN WORKERS OF EQUAL PHYSICAL WORK CAPACITY, UNDER CONDITIONS OF NEUTRAL INCENTIVE

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Chamber of Mines

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and
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Summary and Conclusions

Ten Bantu mine workers were selected so as to match as much as possible in respect of abilities, socio-economic background and work capacity, the latter measured by the individual's maximal oxygen intake. These workers were subjected to repeated testing, according to a random time table, on the Tramming and the Ball Lift and Step Tests. Tramming was carried out at a constant speed, 2½ miles per hour, and with 5 different loads in a one-ton mine car on a level circular track. The Ball Lift and Step Test was carried out at constant speed and at one constant work load.

Very significant differences between subjects were found, in performance (duration for which the subject continued with a given task) as well as in oxygen intake. Both measures were uncorrelated with each other when work load was kept constant. Performance in one task and load was, however, correlated with performance in any other task; the same held for oxygen intake scores. The rank order of subjects, in respect of performance as well as oxygen intake scores, tended to remain the same with low and high work loads on tramming and on the Ball Lift and Step Test; those subjects who did well in one task did well also in others.

Differences in performance between individuals were attributed to differences in drive level, a personal motivational characteristic. Differences in oxygen intake were attributed, tentatively, to function fluctuations, i.e. to the fact that, normally, men do not work at constant rates in continuous work. When confronted with tasks which are to be done at constant speed and work rate, they vary at least in their mode of work which, in turn produces temporary changes in the difficulty of the task and thus changes in the cost of work. It appears that there are individual differences not only in the average drive level, but also in respect of drive level fluctuations which exhibit characteristically different patterns.

THE EFFECT OF MOTIVATION ON OUTPUT IN WORKERS OF EQUAL PHYSICAL WORK CAPACITY UNDER CONDITIONS OF NEUTRAL INCENTIVE

1. PROBLEM

Up to date, no satisfactory measure of motivation exists. The Problem with which we are confronted is to develop methods by which motivation to work, in the present context motivation to do heavy physical work (shovelling rock, pushing mine cars, etc.), can be measured or assessed.

The terms "motivation" and "motivation to work" need clarification. The latter refers, very generally, to any condition which makes a man work. There are mainly two classes of such causes or conditions, namely

(a) external "incentives", i.e. rewards or punishment of some kind, such as pay, achievement or status, social pressure, regulations, etc.: and

(b) internal "drives", i.e. frequency and/or the intensity of impulses within a man which prompt him to be active rather than passive and which keep his activity directed towards an end.

In the present investigation, we are concerned with the latter class of motivating factors, namely those that exist in a human being more or less independently of any incentive that may be offered to him. Some incentives, positive or negative, are never entirely absent under normal working conditions. These give direction to a man's activity and cause him to select one (or some) of the many possible activities which are open to him, namely that which appears most rewarding under the given circumstances. Once a choice has been made, the incentive often seems to have relatively little effect on the intensity with which the chosen activity is pursued (except in the case of an incentive which is systematically varied with the amount or quality of work done, e.g. a bonus system). This intensity is then a function of (i) the individual's "energy resources" (his "drive", "vitality", "will power"); and

(ii) the number of incentives which are effective at any given time, and between which the available energy is to be divided.

In a simplified diagram, we can depict the general motivational situation of a person by a system of vectors, originating from the individual and each aiming at a certain incentive or "goal" (figure 1). The length of each vector indicates the intensity of activity (or tendency to be active) in the direction of this vector. If the end points of vectors are connected by straight lines, these include an area which corresponds to the individual's "energy resources". The greater this area, irrespective of its shape, i.e. the greater the energy or vitality of the individual concerned, the longer may be the vectors, i.e. the more activity can be maintained in the various directions. With a given amount of energy (constant area), the length of a particular vector will to some extent depend on the number and length of other vectors. This means that the amount of activity that can be devoted to a certain goal, will depend not only on the total energy available, but also on how this is distributed over various activities and how many incentives are effective and strong enough to initiate activity.

This model is an over-simplification in a number of relevant aspects. (1) The existence of negative incentives (avoidance of certain activities) is neglected. (2) The interrelations between different goals and the corresponding vectors are more complex than can be shown in a two-dimensional diagram. (3) Although several incentives can be effective simultaneously, they are not <u>all</u> effective continuously; specific goals come into focus and go out of focus periodically. This is particularly true for basic (physiological) needs (hunger, thirst, desire for sleep, etc.), the satisfaction of which acts as a strong incentive at times, overshadowing all others. (4) Goals are not permanent and may be changed for new ones after some time; and some goals may be intermediate in that they provide merely stepping stones for subsequent, usually more important goals. (5) Some activities (e.g. play, exploration or the satisfaction of curiosity) are in themselves rewarding and do not require the existence of an incentive for their initiation, although they do require a certain amount of energy to be maintained.

The above model should be sufficient, however, to show the complexity of the motivation problem. It should be clear that, in order to estimate the effect of an incentive, we have to know which other incentives are effective at a given time and what the energy resources of the individual are. In order to estimate the individual's energy resources, his "drive", correctly, we have to know the relative strength of all or at least of the main incentives which are effective at the time of measurement. And we can measure individual differences in drive only if we can say that other aspects of the total motivation situation are the same for all individuals, are kept constant or, at least, are measured and taken into account.

Furthermore, since no direct measure of drive (or any other aspect of motivation) is as yet available, we shall have to infer the level of drive of an individual from his performance in a standard work or test situation, against the background of his motivation as a whole. Performance in a given task depends on (a) the ability or capacity to do this task (strength, skill, experience, training, etc.) and (b) on motivation in all its aspects. This will make it necessary to keep abilities and work capacity constant or at least to reduce differences in capacity to a minimum, in order to demonstrate clearly any differences in level of drive between individuals.

We can now state our problem more precisely. It is the question:-

Do persons of equal work capacity differ in the 'Drive' aspect of their motivation to work if they are exposed to the same incentives, in particular the same incentive to work?

If the answer to this question is affirmative, we may proceed to the next step, the development of measurements for these kinds of motivational differences. If the answer is negative, we will have to shift the emphasis to the other aspect of the motivation problem, namely that of incentives.

The following experiment was designed and conducted in order to find an answer to the above question.

2. METHOD

2.1 Selection of Subjects

Ten mine workers were selected, from a larger number of recruits, to match as much as possible in demographic, social, psychological and physiological criteria, as follows:-

Tribe:	Nyachusa (Tanganyika)
Age:	± 20 years
School Education:	Nil
Ability:	Low scores on Gen.Adapt.Test Battery (Dudec 10-12)
Mining Experience:	Nil
Work Capacity:	2 l/min maximum oxygen consumption
Incentive:	Normal pay

Low scorers on the General Adaptability Tests were selected because these are normally assigned to non-mechanical, unskilled jobs, such as tramming and lashing. The work capacity, in terms of maximum oxygen consumption, was determined by the method developed by the Applied Physiology Laboratory and described by Maritz et al. (2).

These 10 workers were placed under the supervision of a Boss Boy specially selected for this task. They were housed in a compound at Crown Mines, in the vicinity of the Applied Physiology Laboratory and the tramming track, where the tests were carried out. The Boss Boy was also from Tanganyika and able to speak the home language of the subjects. He saw the men not only at work, but also in the compound, during their leisure time, participating in their conversation, and so on. In this way, information on other activities of the subjects, their attitudes towards work and their interests, was obtained. The Boss Boy tried to make notes on any remarks made by the subjects relating to their ability and willingness to work or containing any criticism of the working conditions.

2.2 Tests and Apparatus

The tests employed were:-

1. Tramming at a constant speed, using 5 different work loads.
2. Ball Lift and Step Test, at a constant speed and constant work load.

2.2.1. The Tramming Test requires the testee to push a mine car, with a certain load, around a level circular track (314 yards circumference) at a fixed speed of $2\frac{1}{2}$ miles per hour, for as long as he can. While he is doing this, he is accompanied by a "monitor", one of the Bantu Scientific Assistants of the NIPR. This monitor has (i) to assist in taking physiological measurements (by sampling of expired air during the 4th to 6th minutes of the work period; controlling the correct position of electrodes; switching on and of the transmitter for heart beat counts at regular intervals via a transmission set); (ii) to guide the subject in maintaining a constant speed of tramming; and (iii) to help push the car out of the track when the testee says that he is unable to continue with his work.

The one-ton mine cars used in this experiment were fitted with speedometers, the dials of which were visible to the testee while pushing the car. The required speed was marked on the speedometer and an additional signal system was provided to facilitate the maintenance of a constant speed. A bell rang as soon as the speed dropped below the required speed and a buzzer sounded as soon as this was exceeded. Subjects were familiarized with this system and tramming at a constant speed was practiced 2 days before the actual experiment was started.

The different loads used and the number of trials carried out per subject with each load were as follows:-

Car chassis without pan	(-460 lbs)	10 trials each
Empty car	0 lbs	10 trials each
Car loaded with	600 lbs	10 trials each
Car loaded with	900 lbs	10 trials each
Car loaded with	1500 lbs	6 trials

These loads were selected, on the basis of preliminary tests with different subjects, in such a manner that a sufficiently wide range of oxygen intakes below the subject's maximum oxygen intake was covered. Note that these loads are additional to the weight of the empty car which is 1000 lbs.

2.2.2. The Ball Lift and Step (B & St) Test requires the testee to pick up a cricket ball from a ball trap on the floor and carry it four steps up to a platform, 40 inches high (about 18" deep). Here he has to drop the ball into the middle one of three apertures in a box mounted at a convenient height at the rear of the platform (3 ft. above it). The ball returns through a chute to the starting point, the ball trap, from where it is to picked up again. This cycle has to be completed in 9.3 seconds. In order to facilitate keeping up a constant work speed, the three apertures of the box on the platform open and close in a certain rhythm, the middle one being open at the right time, those left and right of it when the subject arrives too early or too late on the platform. If this happens, the tester tells the testee to slow down or speed up, as the case may be. During this activity, the subject carries a load of 30 lbs fixed to a belt and supported by shoulder straps. After some practice, this task was performed by each subject for 10 trials, on different days.

2.3 Test Administration and Time Table

The sequence of 56 test trials (46 tramming and 10 B & St trials) for each subject was administered in a predetermined random order, with the restriction that no subject should do more than one test trial on any experimental day. There was one exception, enforced by circumstances; one testee did the tramming 900 lbs in the morning and the B & St in the afternoon of one day in the second last week of the experiment; however, without any obvious effect on performance level. See also below, treatment of missing scores. The experiment extended over 17 weeks, testing being done from Monday to Friday of each week. Test trials on tramming 1500 lbs started 7 weeks later than the others tasks, when the subjects had had some practice on the easier tasks.

On the tramming track, up to three subjects could be tested simultaneously. In these cases different starting times and different work loads were employed, in order to minimize the possibility that one subject might be influenced by the performance of another.

Subjects to be tested on a particular day waited before their test trial, near the tramming track. Before a subject started any test trial, he was told to rest, in a sitting position without talking, for 15 minutes after which his resting heart rate was taken. Thereafter, test instructions were given, his car was put on the track and his test trial started. Subjects who had done their test were employed as helpers for other tests or were kept occupied with other light work (e.g. gardening) for the remainder of the day. On the average, 6 to 7 test trials were carried out per day, so that only 3 to 4 subjects per day were not engaged in being tested. The tramming trials lasted on the average from 50 to about 110 minutes, including the time required for the determination of resting heart rates and other preparatory work. The trials on the B & St test lasted about 50 minutes on the average.

For the determination of heart rates, electrodes were placed on the subject's chest, held in position by an adjustable rubber belt, and connected to a transmission set mounted on the side of the mine car. The receiver was placed in a corrugated iron hut just outside the tramming circle; in this hut all recordings were made of heart rates, performances, conditions, etc. In the case of the B & St test, chest electrodes were directly connected to a heart rate counter, the tester taking care that the leads did not disturb the movements of the subject and did not get entangled with the platform structure or the pipes and Douglas bag used for the sampling of expired air. For air sampling during tramming, Douglas bags were carried on the mine car. Mask and bag were removed by the monitor after the measuring period.

2.4 Instructions to Subjects

English equivalents of the test instructions, given to the subjects in their home language, are reproduced in the

Appendix. These instructions were given before the first test trial and then, in abbreviated form, at the beginning of each week.

2.5 Scoring of Observations and Statistical Analysis of Data

2.5.1. Performance

Since both tests were done at fixed and constant work rates, (an experimental condition required for the control of energy expenditure and physiological cost of work) the possibility of individual differences in performance occurring was limited to the duration of performance. In the present experiment, the measure of performance was the time for which a subject continued work on a given task. Thus, performance reflects "endurance of work output" and not the more conventional aspects of quantity and quality of work output. Performance was measured in minutes and seconds for the B & St and for the first four trials of the four easier tramming tasks; for the later six trials of all tramming tasks, the times were rounded to the nearest full minute.

Frequency distributions of all time scores were made, separately for the two tests and five different loads. For each test and load, the distribution of scores is positively skew, as can be seen in the two examples (figures 2a and 3a) showing the distribution of scores on the Tramming, "load O" (empty car) and on the B & St test. Low scores are relatively frequent, very high scores relatively rare. It was found, however, that a transformation of the time scores into "log time" scores would remove the skewness of the distributions very well and change these into reasonably symmetric normal distributions. The effect of this transformation can be seen in figures 2b and 3b.

Since the statistical methods to be applied to the data, analysis of variance and correlations, are based on the assumption that scores are normally distributed, the transformed scores "log time" were used for these analyses throughout, as well as for most of the graphical representations of results. It may seem that such a transformation would make the observed data less readily interpretable in terms of "actual performance". However, the following should be considered in this context: A period of work, say, five minutes, may have different psychological significance compared with an equally long period, if the work load is different; 5 minutes of heavy work are more severe than 5 minutes of light work. Or, to put it differently, if a task can be performed on the average for about 10 minutes, it will require a considerable effort to continue for another 5 minutes. If, on the other hand, a task can be performed for as long as 100 minutes, another 5 minutes will not matter very much. This is exactly what the log transformation takes into account by giving a lesser weight to differences between long periods of time compared with the same differences between short periods of time.

Measuring performance in terms of "log time" has the additional advantage that the relationship between energy requirements (oxygen intake) and performance takes the form of a straight line with the range of tasks used for the tramming tests, as shown in figure 6. Furthermore, "log time" and "l/min" scores are of a similar order and range which facilitates the investigation of certain combinations of these scores.

2.5.2. Oxygen Intake

The determination of individual oxygen intake scores, in terms of litres per minute, was carried out by the staff of the Applied Physiology Laboratory, using the Douglas bag and Haldane gas analysis methods. The distributions of oxygen consumption scores closely resemble normal ones (except for some unexpectedly high and low scores which may be due to measurement errors). An example of this is the distribution of oxygen intake measurements during the tramming of 0 lbs and the B & St test, shown in figures 4 and 5.

2.6 Treatment of Missing Scores

In a few cases, single trials were not done by the one or other individual, nor could they be fitted into the testing programme on another day, so that the corresponding scores were not known. In these cases, the missing scores were replaced by the individual's average score on that particular task, in order to keep the computational procedures as simple as possible, avoiding unequal numbers of scores. The more complex estimation of missing scores by means of Snedecor's formula (4) was not employed because of individual differences in trends over trials. It did not seem advisable to assume that one individual's practice trend was the same as that of the whole group (cf. below, 3.6.).

In one case (subject B, bottom part of table III) two measures of oxygen consumption seemed to be entirely out of step with the other scores of that column in which, in addition, one score was missing. In this case, the two questionable scores and the missing one were estimated by means of the average of the three remaining scores and the individual's trend over all tramming tasks. The replaced scores (1.62 and 1.56), although somewhat arbitrary, seem to be more reasonable than the original ones (2.45 and 2.86) which far exceed this individual's oxygen intake even on the heaviest tasks.

In our tables, estimated scores are in brackets, scores which possibly contain measurement errors are marked by a question mark. Altogether 7 missing performance scores and 15 missing or doubtful scores of oxygen consumption, each out of 560, were replaced by estimates.

2.7 Statistical procedures

As a first step of the analysis, data were plotted on graph paper; graphical analysis of trends and bivariate distributions of scores supplemented the computations at all stages (see figures).

The significance of variations in both performance and oxygen intake between individuals (individual differences) and between trials (general group trends, e.g. practice effects) was established by two-way analysis of variance. Firstly, 12 such analyses, 6 of performance scores and 6 of oxygen intake scores, were done separately for each of the different tests and loads. Secondly, 20 similar variance analyses, 10 of performance scores and 10 of oxygen intake scores, were carried out to test the significance of individual trends, i.e. changes common to an individual's sequences of trials on different tasks, separately for each of the 10 testees.

Correlations between performance, oxygen intake and certain combination socres, each on the various tasks, served to determine the reliability of scores and to study to what extent differences between subjects could be due to "individual characteristics".

Performance scores were also converted into standard measures in order to determine unusual performances and to study their relationship if any to the subject's personal condition on that particular day, as observed by the boss boy.

Since it was expected that training effects would be marked during the first weeks of the experiment, and since the 1500 lbs tramming was started later than the other, easier tramming tasks, the first 4 trials on each of the latter were separated as a "training period" from the "main experiment". The variance analyses and intercorrelations of tramming scores were restricted to those of the main experiment. In the Ball Lift and Step test no training or practice effects were observed; all trials of this test were therefore analysed together.

3. RESULTS

All observations, performance in terms of log time and oxygen intakes in terms of litres/minute, are tabulated in tables I to VI, (a) and (b), respectively. The body of these tables contains scores obtained from single trials of one individual on one particular task. The right hand marginal columns, headed "Mean", contain the mean scores of 10 individuals on all first, second, etc., trials with one particular test and work load. The rows "Average, Training" and "Average, Main Experiment" contain the average scores of one individual testee on a sequence of trials with the same test and load. The grand totals, to the right and at the bottom of each set of data are the arithmetic means of all data (40, 60 or 100) in that part of the table.

3.1 Relationships between Performance, Oxygen Intake and Work Load

3.1.1. (1) With varying loads

As expected, performance decreases and oxygen intake increases significantly with increasing work load. This is shown in figure 7 in which the grand totals of the main experiments on tramming (i.e. excluding the training part of the tests), table I - VI, are plotted against the corresponding work loads. Work load "0" designates the tramming of the empty mine car, work load "-460" that of the car chassis without the pan. The confidence belts on either side of each curve (not shown in the graph) are relatively wide. The standard deviations, bas d on the total variance (betwwen individuals, between trials, error) of each set of 60 scores, range from .170 to .266 for performance (log time) and from .170 to .261 for oxygen intake (l/min), the latter after correction of some extreme scores which contained measurement errors.

It may be of interest to compare the oxygen intake curve of figure 7 with the diagrams presented in A.P.L. Report 12/63 (54), dealing with the effect of lubrication on energy requirements of tramming various loads, at a speed of 2 miles/hour. It will be seen that the curve obtained from the present data, tramming at 2½ miles/hour, extrapolated to the left would cut the ordinate at a higher point, at about .8 to .9 l/min, compared with .4 to .7. The ordinate in the graphs is placed at an abscissa value of "zero total weight" (= weight of car plus load), i. . a work load corresponding to walking at the given speed without pushing anything. Compared with oxygen intake figures for plain walking (.74 to .77; cf. Passmore and Durnin (3), p.806), our oxygen intake values seem to be slightly on the high side, and even more so when we consider that our subjects are of relatively low body weight. This relatively high energy expenditure can not be due to bad lubrication, which would increase the slope of the curve and thus give a lower ordinate cutting point. It could be due to roughness of the surface between tracks and to a certain amount of energy being required for speed regulation. The slope of our curves seems to be intermediate between those of the extreme lubrication conditions of A.P.L. Report 12/-63, figure 1 (a). Lubrication in the present experiment was done as required and determined by frequent inspections of the car bearings, but not at regular intervals, sometimes more, sometimes less frequent than once a day. It is possible that lubrication defects introduced some proportion of error into our observations.

The performance curve is more or less a mirror image of the oxygen intake curve, perhaps slightly more curved than the latter. Extrapolating to the right, a load of 2000 lbs would be pushed under the conditions of this experiment for about 16 minutes and at an oxygen intake somewhat above 2 l/min, the initial maximum oxygen consumption of these men. Extrapolating to the left, the curve would indicate that, on the average, our subjects would continue walking without any load for about 100 minutes. This is certainly less than they are capable of and indicates the presence of some limiting motivational factor.

3.1.2 With constant load

If we consider the relationship between performance and oxygen consumption within one constant load condition, we find that there is no consistent correlation between these two measures. That is to say that men who have a higher average oxygen intake do not perform consistently or on the average better (or consistently poorer) than men having a lower average oxygen intake on a given task. This is exemplified in figures 8 a, b and 9a, bivariate distributions of scores on tramming 1500 lbs, the B & St test and an average of all tests. The same fact is shown, more comprehensively, in tables IX and X which give the product-moment correlation coefficients between performance and oxygen intake scores (see below, 3.4). There is no pattern in the relevant coefficients of table IX, in other words, the size of these coefficients is not related to the type or difficulty level of the task. We can state from these findings that oxygen intake and performance in a constant task, such as each of those under investigation, and under the conditions of this experiment are essentially uncorrelated.

3.2. Analysis of Variances, "Between Subjects" and "Between Trials"

Each set of scores obtained in the main experiments on tramming and in the whole Ball Lift and Step experiment was subjected to the same kind of variance analysis.

The results are compiled in tables VIIa, performance scores, and VIIb, oxygen intake scores.

Table VIIa shows that, in each of the test tasks, the variance between subjects is significant, relative to the interaction subjects x trials which serves as an estimate of error variance. Individual differences in performance are most marked in tramming 600 lbs, 900 lbs and in the B & St test: they are less marked, but still significant at least beyond the 5% level, in the two easiest and the one heaviest tramming tasks. The variance between trials, indicating a trend common to all subjects, from trial to trial, is not significant for the easy tramming tasks, -460 lbs, 0 lbs and 600 lbs, and also not for the B & St test. The variance between trials is significant in tramming 900 lbs and very much so in tramming 1500 lbs.

Table VIIb shows a slightly less regular pattern as far as the variance of oxygen intake scores are concerned. The variance between subjects in oxygen intake during the tests is most marked for the B & St test and is also very significant for tramming 1500 lbs. For some of the easier tramming tasks, viz. - 460 lbs and 600 lbs., it is significant, for others, 0 lbs and 900 lbs, it is not significant. The variance between trials is very significant in tramming 1500 lbs, even more so in tramming 600 lbs; it is also significant in tramming - 460 lbs. No significant variance between trials was found for tramming 0 lbs, 900 lbs and in the B & St test.

The square root of the ratio: variance between subjects to error variance can be regarded as an indicator of the discriminative power of a test measure. Taking the square roots of the entries in the column "F ratio" of tables VIIa and VIIb and plotting them against load, we obtain the diagram shown in figure 10. (The position of B & St on the abscissa is estimated on the basis of the average oxygen intake in this test). This indicates that, for easy tramming tasks, the performance scores give a better discrimination between individuals than oxygen intake. The reverse holds, however, for the heaviest tramming load and the B & St test. The latter test seems to be better, as a measure of individual differences, than most of the tramming tasks.

3.3 Estimates of Test Reliability

The reliability of each of the test tasks was determined from the correlation between three odd (sum of trials 1,3,5) and three even (sum of trials 2,4,6) trials (5 odd and 5 even trials in the case of the B & St test). The correlation coefficients, here considered as equivalent to reliability coefficients, are given in table VIII and are plotted in figure 11. This graph is very similar to that of figure 10, except that performance scores in tramming -460 lbs yield unusually high, tramming 0 lbs unusually low odd-even correlations. For performances in tramming, -460 to 900 lbs, correlations between average training and average main scores are also given. These, based on 4 early and 6 later observations, give slightly higher estimates of reliability.

It should be noted that no corrections, by means of the Spearman-Brown formula, were made, since the correlations are based on pairs of at least 3 test trials, which is more than is normally available for purposes of prediction.

All correlations indicate a satisfactory level of reliability. A set of three trials of a given task, such as tramming or B & St test, measures individual differences in performance and oxygen intake reasonably well and, from one set of three trials to another on the same task, the order of subjects from best to poorest remains more or less the same.

3.4 Intercorrelations of Performance and Oxygen Intake Scores Measured by Different Tasks

The results so far have shown that (a) significant individual differences in performance on all and in oxygen intake on some tasks occur (significant "between subjects" variances); and (b) the tests employed seem to be sufficiently reliable as measures of individual differences (correlations between odd and even trials). It should now be investigated whether these differences go beyond the particular task in which they are observed, i.e., whether they can be regarded as characteristics of the individual, stable enough to have an effect at least on tasks of the same type varying in difficulty or on similar tasks. Relevant information is obtained from correlating average performance, oxygen intake and some combinations of these on one task with the corresponding averages on another. (The basic data are pairs of scores from any two tables (I to VI), e.g. row "Average, Main Exp.", table Ia, scores for individuals A, B, etc., with the corresponding scores of table IIa, IIIa, etc., or IIb, IIIb, etc.)

In addition to the straightforward performance and oxygen consumption scores, two sets of combination scores were used, viz. the sum and the difference of these two measures. This transformation of the original scores into combination scores does not, of course, add anything new to our observations. It merely means looking at the same data from a new angle.

The sum of performance and oxygen intake(both measured on comparable,more or less linear scales, see above, 2.5) would indicate that a subject performed well at high energy expenditure if this sum score was high; and that he performed poorly at low energy expenditure if the sum score was low. In the former case, it was felt, he put up a good effort and in the latter case a poor effort. It is proposed to call this combination score, tentatively, "effort". An example of "effort" scores in tramming -460 lbs for subject A would be P + O = 2.01+1.00=3.01 (table Ia and Ib, row "Average, Main Exp."); for subject B, P + O = 1.71+1.06=2.77; and so on.

A large difference, performance minus oxygen intake, would indicate a good performance which was done at low cost (energy expenditure); a small difference, occurring with low work loads, or a negative difference, with high work loads, would indicate a poor performance in spite of relatively high energy expenditure. The larger this difference, P - O, the easier, the smaller or the more negative the difference, the harder, it seems, is the task for the subject. One might regard this difference as a measure of work economy relative to the level of difficulty of the task. It is proposed to lable the difference, P - O, for the purpose of this investigation as "Reserves", a large positive difference indicating a high amount of untapped resources or energy reserves. An example of scores "Reserves" in tramming -460 lbs for subject A would be P - O = 2.01 - 1.00 = 1.01 (table Ia and Ib, row "Average, Main Exp."); for subject B, P - O = 1.71 - 1.06 = .65; in tramming 1500 lbs, subjects A and B would have the following "Reserves" scores: 1.44 - 1.60 = -.16; and 1.08 - 1.95 = -.87 (table Va and Vb, last rows). It can be seen that the score "Reserves" is a relative measure and becomes negative in the case of heavy work load. (Negative scores of "Reserves" could be avoided by adding a constant to all scores; in some cases it might be useful to add the subject's maximum oxygen intake to the difference P - O. Maximum oxygen intake is constant in our subjects.)

All possible intercorrelations between performance, oxygen intake, "Effort" and "Reserves" scores are compiled in table IX. This table is subdivided into blocks, each block dealing with one type of score and containing the 5 different tramming tasks and the B & St test. A summary of table IX is provided in table

X which gives the average correlation within each block of table IX, based on 15 correlation coefficients in the diagonal blocks and on 36 coefficients in the case of the other blocks. The diagonal cells, from top left to bottom right hand corner, within the second block in the first column of blocks contain the correlations between performance and oxygen intake measured on the same task. The corresponding diagonal cells of all other blocks to the left and below the diagonal blocks contain a part-whole correlation, i.e. the size of the correlation coefficient is influenced by the common element in both variables, such as P correlated with P + O. In general these coefficients tend to be higher, in absolute value, than the other coefficients of the same block which are free from part-whole components.

Of special interest for our problem are the four diagonal blocks, performance on one task correlated with performance on another, oxygen intake in one correlated with oxygen intake in another task, and so on.

It can be seen from table IX that these four blocks contain only positive correlation coefficients and that these coefficients are more similar in size, i.e., they vary over a smaller range, than those in other blocks. The fact that all correlations are positive is in itself significant. The average correlations within each of the four diagonal blocks are significant at the 5% level (the one-tailed significance test is appropriate here, because only positive correlations are expected and, in fact, observed). The number of individual correlation coefficients which reach this level of significance is (reading from top left to bottom right, from the diagonal blocks) 12/15, 7/15, 9/15 and 13/15, respectively, i.e. 68% compared with the chance expectation of 5%. In other words, those subjects who perform well on one task tend to perform well also on another, easier or heavier, task or on a task of a somewhat different nature (tramming vs. B & St). Similarly, those subjects who have a high oxygen intake in one task tend to have a high oxygen intake also in other tasks. And, looking at our data from the point of view of "Effort" and energy "Reserves", those who make a strong effort in one task tend to make a strong effort in other tasks, and vice versa; those who have relatively more energy to spare in one task tend to have greater reserves in other tasks as well.

Of the other correlations in tables IX and X, those between performance measures on the one hand and oxygen intake measures on the other are of interest. In table IX, second block first column, the majority of these correlations is small and negative, only one (out of 36) reaching the 5% level of significance. (The two-tailed test is applicable, because no prediction of the direction, positive or negative, of the correlations could be made.) The average correlation between performance in one task and oxygen intake in the same or another task is -.086. As stated above, there is no consistent correlation between performance and oxygen intake. The correlations between "Effort" and "Reserves" are on the average positive, but insignificant, only four (one-tailed test) or none (two-tailed test) out of 36 being significant at the 5% level. The average correlation in this block of table IX is .165.

The correlations between performance and oxygen intake on the one and "Effort" and "Reserves" on the other hand need not be considered here, because of their part-whole relationship and the influence of "spurious" correlation. Since the scores "Effort" and "Reserves" are combinations of the other two measures, it is obvious that they must be correlated with these, their components.

3.5 Group Trends

It was found that the variance between trials was significant in some cases of tramming (table VII), especially with the heavier loads, 900 lbs and 1500 lbs. This indicates changes, which are common to all subjects, in performance and/or oxygen intake, from one trial to another. If we plot the group means of trials (right hand marginal values, tables I - VI) in the order from the first to the last trial, separately for each task, we obtain the picture shown in figure 12, a - f. Each point of these curves (performance = full line; oxygen intake = broken line) is the mean of ten subjects' scores on one trial and one type of task. (The right hand part of each curve, covering the main experiment, trials 5 - 10, can be regarded as an elaboration of one corresponding point in figure 7. The ordinate of a point in figure 7 is equal to the average ordinate value of the corresponding curve in figure 12, a-f.)

Some curves of performance, viz. 12a, 12b and perhaps 12c show a rising tendency from early to later trials. Similarly, some curves of oxygen intake, viz. 12a 12b and perhaps 12d, show a falling tendency from the first to the last trial. The trends, upwards for performance and downwards for oxygen intake, are especially clear in the curves of the two heavy tramming tasks, 900 lbs and 1500 lbs. They are probably the effects of practice and increasing fitness which enables the average subject to do a certain task, especially some heavy tasks, increasingly better or with greater ease over subsequent trials. In some cases, viz. tramming 0 lbs, 600 lbs and B & St test, clear trends do not appear or are disturbed by marked irregular fluctuations. An explanation for these fluctuations cannot be offered. They may be caused partly by unintended changes in the testing conditions (e.g. bad lubrication of the car in tramming). In the case of oxygen intake scores, e.g. during tramming 600 lbs, fluctuations may reflect, to some extent, fallible measurements.

If, instead of performance and oxygen intake, combination scores are plotted (figure 13, a - f), it is seen that the difference score (P - O, "Reserves") shows more clearly an upward trend in all tasks but tramming 0 lbs and B & St. Again, this is shown more clearly in the heavier tramming tasks, 900 lbs and

1500 lbs, than in other cases.

On the other hand, the sum score (P + O, "Effort") remains more or less constant over the sequence of successive trials, apart from minor fluctuations (figure 14, a - f). As the experiment progresses, the tests seem to become more and more easy for the group of subjects, but these do not seem to step up their efforts.

3.6 Variance Analysis within Individuals. Individual Trends

By regrouping the data of table I - VI, separately for individuals instead of loads, we obtain a set of 20 smaller tables, 10 of performance and 10 of oxygen intake, of which the rows contain all first, second, etc., trials of a subject, the columns his trials on different loads of tramming.

These tables (not reproduced here) were subjected to variance analysis in order to test the significance of individual trends, i.e. an individual's tendency to improve or otherwise change his performance and oxygen intake, now averaged over tasks, from the first to the last trial. This variance analysis (table XI a, b) shows at the same time the significance of differences between scores obtained from different loads. These, we would expect to be highly significant, because of the variations in load, i.e. in the difficulty of the tasks. In general, the F ratios for variances due to load differences are very large and highly significant. An exception is found in the performance scores of subject D whose rather large fluctuations (see Fig. 15) increase the error variance so much that neither the variance between loads nor that between trials is significant.

As far as the variance between trials is concerned, we find significance at the 5% level in the sequences of performance scores of 2 subjects (out of 10), viz. subjects C and J; in oxygen consumption scores, 2 subjects, viz. B and I, show variances between trials which are of borderline significance, $P_F < 10\%$

There are two aspects of the experimental design employed in this investigation which must counteract the appearance of significant individual trends, namely (1) the variations in work load and (2) the randomization of the sequence of tasks with its variation in time intervals between trials. If nevertheless some significant trends occur, it seems justified to inspect these more closely. This was done by graphical analysis and by correlating the trends over trials of the performance scores on the 1500 lbs and 900 lbs tramming. These two heavy tasks were singled out because it was felt that heavy and easy taks might evoke different types of trend; the former might, for instance, involve more "learning" than the latter.

Figure 15 shows sets of 5 performance curves for each individual. The two upper curves represent the sequence of trials for tramming 1500 lbs and 900 lbs, the three lower curves represent the corresponding sequences for the other tramming tasks. Only the six trials of the Main Experiment are plotted. It should be noted that the abscissa reflects the serial numbers of trials, not time intervals which are unequal and may well be responsible for some of the irregularity in the curves. In spite of this, some striking similarities of pattern exist in some pairs (or triples and even quadruples) of curves. Examples are found in the assemblies of curves of subjects A,B,C and H for the heavy tasks (upper curves); and of subjects C,F,H and J for the easier tasks. The correlation coefficients are entered on the graphs for the pairs of 1500 lbs and 900 lbs curves. The majority of these coefficients is positive, two of them significantly so (subjects A and B), and the average correlation is positive. The general pattern of the trends over trials exhibited in these groups of curves is different from individual to individual; and it has in most cases hardly any similarity to a "learning curve".

The oxygen intake curves, for the two heavy tramming tasks only, are plotted in figure 16. The picture is similar to that presented by the performance curves. Again some striking pattern similarities occur, e.g. those of subjects C,D and J. The same holds for curves of the combination scores, "Effort" and "Reserves". However, because of missing scores of oxygen intake, this analysis is not carried any further.

3.7 Unusual Performances

The observations on the subjects' state of health, mood, willingness to work, etc., as made and recorded by the Boss-Boy of the group, were compared with any unusually good or unusually poor performance. The latter were determined by means of control charts, one for each individual, in which performances of the main experiment were entered in standard measures ($z = \frac{X - \overline{X}}{SD_X}$), after the completion of the whole testing programme. The standardization was done separately for each load and test.

The Boss-Boy's diary contained relatively few observations relevant to the work situation. The following are examples:-

(i) Before work. Subject D "dreamt evil spirits last night, he could not sleep very well and today he feels drowsy."

The actual performance, tramming 600 lbs, following the bad night was 1.73, the subject's best performance during the training period. His averages are: training 1.54, main exp. 1.70.

(ii) After work. Subject B "says that the work of tramming is too hard when there are weights in (the car)".

The performance on this day, tramming 1500 lbs for the first time, was .90, corresponding to a standard measure of z = -1.92. His second performance on the same task was also .90.

(iii) Before work. Subject H "feels pain in his right ear." His performance on this day is his poorest on the B & St test, 1.02, z = -1.89.

(iv) Before work. Subject F "says his work of the tramming track is too hard for him, when we put 1500 lbs (into the car). So he says he will be doing just (a) few minutes when we load 1500 lbs."

The actual performance of this subject on this day, tramming 1500 lbs, was slightly above average, 1.46, z = +.26.

(v) Before work. Subject H "is too happy to-day because of women who pass near the road; he likes to escort them."

Performance on this day, tramming 900 lbs, was 1.65, z = +.32, slightly above average.

(vi) After work. Subject F "Received a letter from home ... At home they are all right ... is happy to-day."

Performance on the following day, B & St test, was his best performance on any test, 1.61, z = +2.18, the third best performance observed on the B & St test.

(vii) After work. Subjects B, E and I "said one of the trucks is too hard to push."

On this day, performance of B, tramming 600 lbs, was .90, z = -2.74; performance of E, tramming 1500 lbs, was .70, z = -2.70; performance of I, tramming 600 lbs, was 1.08, z = -2.07. The oxygen intake scores were very high for B and I; that of E could not be measured because of the short duration (5 minutes) of his work.

Performance of I on the day before, tramming 1500 lbs, was .90, z = -1.92, but with an oxygen intake below average, i.e. the task being experienced as not unusually difficult.

Many more examples could be given of diary entries referring to minor health complaints (headache, cold, upset stomach, etc.); to spontaneous expressions on the part of subjects of "happiness", sleepiness, lack of strength; about meeting friends; about quarrels with fellow subjects, and about general complaints or conversations. Only very few of these are made at the time, shortly before or after outstanding performances and are relevant to work.

If we regard as "unusual performances" those that occur with a probability of 5% or less, we can expect about 28 such unusual performances for our set of 560 test performances done by the whole group, or about 3 unusual performances per subject. We have counted on the control charts 29 outstanding performances (including a few which come near the required level of 5% probability). Of these, 6 can be regarded as related to relevant observations, i.e. entries in the Boss Boy's diary. In some cases, the relation is contrary to expectation (see examples (i) and (iv) above). There is no indication that unusual performances must be attributed to extraneous factors.

4. DISCUSSION

The experimental design of this investigation provided for subjects of equal work capacity and abilities to do certain simple tasks. These were selected so that they required no specific skill or training beyond the natural physical abilities of a normal man, viz. the ability to walk and push a car on a level surface; to walk up steps; and a certain amount of body control for picking up an object from the floor, turning, walking at a constant speed, etc. Measuring performance in terms of duration of activity in a given task set at a fixed level of difficulty, was a further means of minimizing the effect of skill differences. It was expected that men of equal work capacity working on such simple tasks would perform equally, if they were equally motivated. If they were working under the same external incentive condition and matched for ethnic and socio-economic background, their performances should not differ very much except by virtue of some internal motivational differences. The purpose of this investigation is to demonstrate, by carefully controlled experimentation, whether such internal motivation differences, which we propose to call differences in drive level, exist or not; and whether these, if they exist, can be regarded as personal characteristics of individuals.

We do not know exactly how efficient our selection and matching procedure was, and how strictly our condition, of equal capability and equal attitude to work, was met. However, it is unlikely that, in a normal work situation or in any other experimental situation, we would find workers more alike in these respects than our group of subjects. We can assume that our subjects were as equal as we can possibly find them in respect of their capability of doing and attitude towards moderately hard physical work.

In each of the six different test tasks we find very significant differences in performance between these relatively equal men. These differences are large indeed: the poorest performance of the best performer is better than the best performance of one or two of the poorly performing subjects; this holds without exception for all tasks. We find, furthermore, that these differences are not systematically related to the amount of energy required for carrying out the tasks, as measured by oxygen intake during work. The correlation between performance and oxygen consumption is only very slightly negative. This makes it unlikely that marked differences in skill are involved, because these, in a physical task, should be reflected in energy requirements. And, although significant differences in oxygen intake are found between subjects of our group, these cannot, because of the negligible correlation with performance, be responsible for the observed performance differences. We have to conclude that a major portion of the performance differences between our subjects is due to differences in drive level.

Corroborative evidence is found in the fact that performance in one task is always positively correlated, significantly on the average, with performance in any of the other tasks. The average correlation between performance in any two tasks is about .65. The square of the correlation coefficient is equivalent to the proportion of variance which two scores have in common; $(.65)^2 = .42$. Thus, the proportion of common variance between tasks such as those used in the present experiment would be about 42%. If, on the basis of above and below average performance in one task, predictions had to be made about above or below average performance in another task, we could expect to be correct in 70% to 75% of the cases. It should be remembered that we are dealing with scores determined by the length of time for which the subject continues working. Such scores, although they have the advantage of being relatively insensitive to skill differences, are usually not as reliable as scores determined by the amount of work done in a given period of time. There are probably a number of minor factors which can influence the timing of the decision to "give up" and thus the duration of an activity, especially if the task is well within the capacity of the subject. But even so, with scores of relatively low reliability, the intercorrelations found between tasks are substantial. They indicate that the differences in performance between subjects are due to fairly stable individual characteristics. The rank order of performance in our group of subjects tends to remain the same, from one test, tramming, to another, the Ball Lift and Step test; and within the tramming situation, from one level of difficulty (about 50% of the individual's maximum work capacity) to another (70% to 90% of the maximum capacity).

Performance differences between subjects appear to be most marked on moderately difficult tasks (see figure 10), such as tramming 600 lbs, 900 lbs and B & St test. At a high level of difficulty (tramming 1500 lbs) physical limitations seem to restrict the range of individual differences, because all subjects work close to their maximum capacity. Individual differences in oxygen intake, on the other hand, are most noticeable in the heaviest tramming task and, very pronounced, in the B & St test. The latter, work at speed and against gravity, involves anaerobic muscular activity.

It is not possible to say definitely why on the easier tasks (tramming the empty car and the chassis), in which physical limitations must be unimporant, individual differences in performance are not revealed more clearly. The reason lies probably in the fact that performance in these tasks, not representing a real challenge to the subjects, is reduced to a kind of "token performance". The subject stops working not because he is exhausted, but because he feels "this is enough to show I can do it". With productive work, this might be different; but our tests are obviously non-productive and artificial. The mean performance at the low level tasks is much lower than what is physically possible; working at an oxygen intake level of 50% of the maximum oxygen consumption for a full work shift (8 hours) should be no serious problem. Our subjects, in a kind of trade unionist attitude, apparently agree, tacitly, that they must not do too much lest they have to do it every day. They set themselves an acceptable norm according to which they work, relatively homogeneously, but maintaining a rank order similar to those in other tasks. It is noteworthy that the lowest variability, between subjects and between trials, is found in tramming 0 lbs, i.e. the empty car.

The large individual differences in oxygen intake are surprizing in view of the fact that all tests were done at constant work rates. The coefficient of variability of individual averages (of 6 trials) is 20.4% for the tramming tasks (ranging from 18.3% to 21.1%)and 27.2% for the B & St test (averages of 10 trials). Within subjects variability, i.e. between trials, is of the same order, on the average 23.9% (ranging from 15.9% to 34.8%), in the tramming tasks; it is lower, 9%, in the B & St test. For the tramming tests, it does not seem plausible to assume that differences in oxygen intake on the same task have to do with mechanical efficiency. If this were so, the variations between trials should be much less than those between subjects, at least in those easier tasks in which no consistent trends, improvement with practice, occur. However, individual differences in mechanical efficiency appear to exist in the B & St test. In this test, the ratio of variance between subjects to that between trials (9.2) as well as to the error variance (16.9, see table VII) is extremely high. A small proportion of the differences in oxygen intake could be due to fallible measurements (like those indicated by question marks in table I to VI). However, measurement errors as well as uncontrolled changes in testing conditions (procedural defects, such as lack of lubrication) should inflate the error variance and thus reduce the significance of variance between subjects and between trials. This is not the case, error variance for the different tramming tasks are small and cover but a small range (from .022, load -460, to .054, load 900).

Thus, the results show that significant individual differences between subjects occur not only in respect of performance, indicating characteristic differences in drive level, but also in a second factor, measured by oxygen intake, which is independent of the first and yet equally characteristic of the individual. This two-factor situation does not change when the original performance and oxygen intake scores are transformed, by combining them, into a sum and a difference score. (This transformation is analogous to the use of a height/weight ratio plus some measure of body size, e.g. volume or surface, instead of the primary measures of height and weight.) With transformed scores, again two essentially uncorrelated factors are necessary to account for the observed individual differences. For these, the interpretations suggested are (i) "Effort", perhaps even more a reflection of drive level than performance; and (ii) "Reserves", i.e.

an aspect of work economy. Whereas both original scores show practice effects over the sequences of trials, the transformed score "Effort" remains more or less constant; and the score "Reserves" shows practice effects more clearly than performance and oxygen intake.

There is evidence that individual differences occur in a further aspect, namely periodic fluctuations in both performance and oxygen intake. Besides the slight practice trends, common to all subjects, characteristic individual trends appear, linking two or more of the tramming tasks by a similarity of pattern in the sequences of six trials during the main experiment. The statistical significance of these individual trends could only be demonstrated for some of our subjects, due to restrictions of the experimental design, in particular because of the randomized time table of trials. However, the similarity between some pairs of sequences appearing in figures 15 and 16 can hardly be attributed to chance. And these trends, if characteristic for individuals, might provide an answer to the question why significant differences in oxygen intake occurred between individuals, and within individuals from one trial to another, in spite of constant work rates.

Normally, human beings working at a self-determined pace do not maintain constant rates in continuous work of any kind. There are fluctuations in continuous work, the intensity (amplitude) and periodicity (wave length) of which varies from one person to another. But fluctuations are never absent and, in continuous work of a suitable kind, can be measured readily. It can also be shown that apparently irregular fluctuations are usually compounded of a number of rhythmic and more regular changes of varying wave length (1). It is a common experience that all basic drives in human beings (hunger, thirst, the need for sleep, etc.) are subject to rhythmic changes. We cannot assume that motivation to work, i.e. drive level, makes an exception.

Our experimental psychological work with continuous test activities has produced evidence that some of the rhythmic components of such activities have temperamental implications. For example, in one experiment with students, tested in a continuous addition test before undergoing a strenuous acclimatization course in the hot climatic chamber, it was found that a certain rhythmic component of about 18 minutes wave length was significantly correlated with motivation self-ratings of these subjects.

In the present experiment in which subjects were not allowed to change their rate of work, they could only vary in overall performance and in their mode or technique of work. The former kind of variation is demonstrated by the results reported above. The latter type of variation, if it occurs, might well cause changes in the difficulty of a task and thus bring about the fluctuations in oxygen intake observed in the present experiment. At one stage during similar tramming experiments, observations were made on the number of steps taken by the subject while circling the tramming track. The number of steps made between two points of the circle were counted and recorded each time a subject passed this part of the track. Not only did the subjects differ greatly in their average number of steps, or its reciprocal average step length (104 to 131 steps per unit distance were observed in a small group of subjects), but it was also found that within one trial the step length varied as much as about 10% of the average step length, from one round to the next on the circular track, although a constant speed was maintained. Some subjects tended to decrease, others to increase their step length from the beginning to the end of the counting period (about 40 minutes); again others increased and decreased step length once or more times during one trial. These observations merely serve to indicate that considerable variations (probably not only in step length) may take place within tasks which are done, outwardly, at constant rates. In which way these variations are related to the difficulty of the task, to drive level and other functions will have to be investigated by further research. Information in this respect is needed because it is likely that the reliability at least of some of our measurements in this field will be influenced by such fluctuations. The analysis of physiological observations (pulse rates taken at regular intervals) during work at constant rates, and experiments similar to the present one, but arranged with systematic (not randomized) time-tables and regular intervals between corresponding trials, appear to be fruitful in this respect.

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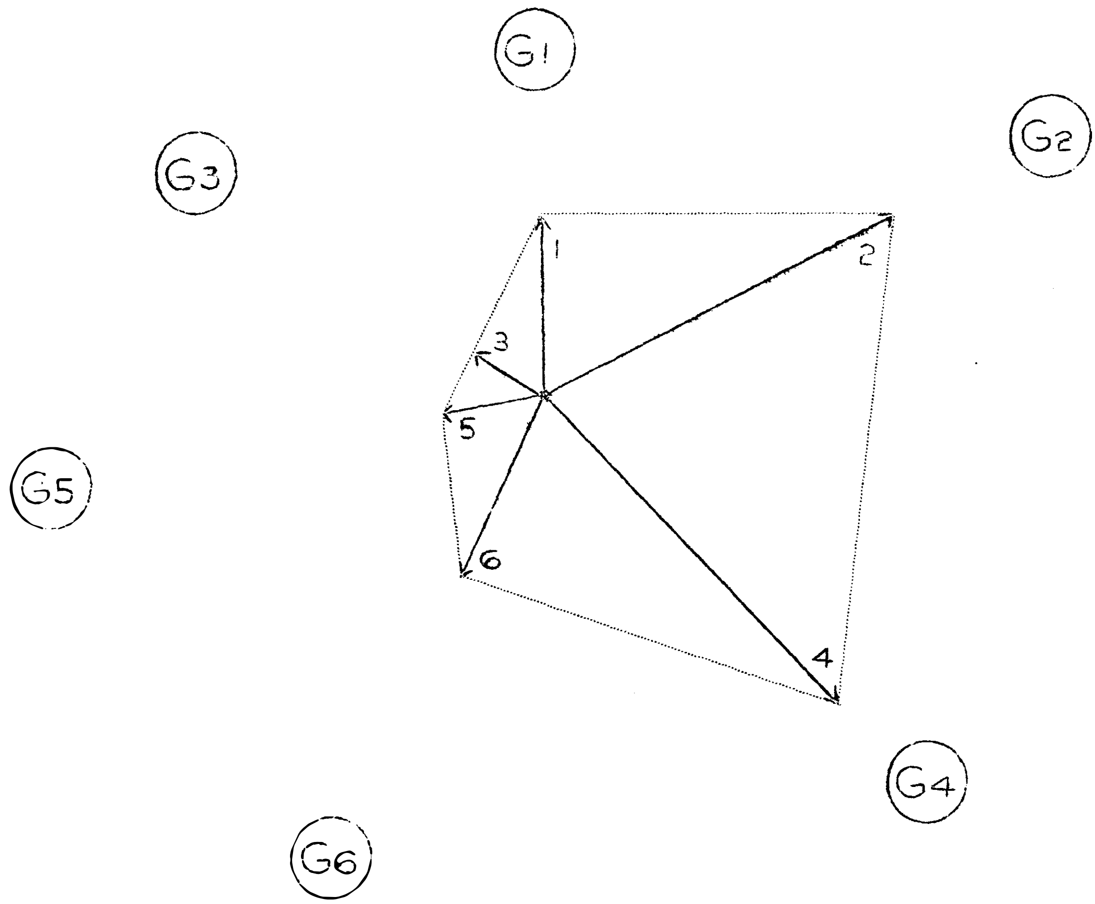


Figure 1. Schematic representation of an individual's motivation. G_1 , G_2 , etc., represent incentives or goals. The vectors (arrows) 1, 2, etc., of varying length represent activities of varying intensity in the direction of the goals. The area between the vectors corresponds to the individual's "energy resources".

Score:	Frequency:	
144-158+	:.	3
129-143		
114-128	:.	3
99-113	::::	8
84- 98	::::.	9
69- 83	:::::::.	15
54- 68	::::::::::.	21
39- 53	:::::::::::	22
24- 38	::::::::·	17
		98

Figure 2.a.

Frequency distribution of scores "time" (minutes), Tramming 0 lbs (empty car)

Score:	Frequency:	
2.13-2.22+	:.	3
2.03-2.12	::	4
1.93-2.02	::::::::	16
1.83-1.92	::::::::	16
1.73-1.82	::::::::::.	21
1.63-1.72	::::::::	16
1.53-1.62	::::·	9
1.43-1.52	::::·	9
1.33-1.42	::	4
		98

Figure 2.b.

Frequency distribution of scores "log time" (log minutes), Tramming 0 lbs.

Score:	Frequency:	
45.0-49.9	:	2
40.0-44.9	.	1
35.0-39.9	:	2
30.0-34.9	:::.	7
25.0-29.9	::::	8
20.0-24.9	::::::::::::::	28
15.0-19.9	::::::::::::::::	32
10.0-14.9	::::::::·	17
5.0- 9.9	:	2
		99

Figure 3.a.

Frequency distribution of scores "time" (minutes), Ball Lift and Step Test.

Score:	Frequency:	
1.58-1.65+	:.	3
1.50-1.57	:::	6
1.42-1.49	:::::	10
1.34-1.41	::::::::	16
1.26-1.33	::::::::::::::·	29
1.18-1.25	::::::::	16
1.10-1.17	:::::·	11
1.02-1.09	:::	6
<.94-1.01	:	2
		99

Figure 3.b.

Frequency distribution of scores "log time" (log minutes), Ball Lift and Step Test.

Score:	Frequency:	
1.56-1.65+	::	4
1.46-1.55	::	4
1.36-1.45	::::	8
1.26-1.35	::::::::::.	21
1.16-1.25	:::::::::::::	26
1.06-1.15	:::::::::::	22
.96-1.05	::::	8
.86- .95	:·	3
<.76- .85	:	2
		98

Figure 4.

Frequency distribution of scores oxygen consumption (l/min), Tramming 0 lbs (empty car).

Score:	Frequency:	
1.88-1.97+	:.	3
1.78-1.87	:::	6
1.68-1.77	::.	5
1.58-1.67	::::::::::::::	28
1.48-1.57	:::::::::::::.	27
1.38-1.47	:::::::::·	19
1.28-1.37	:::·	7
1.18-1.27	·	1
<1.08-1.17	:·	3
		99

Figure 5.

Frequency distribution of scores oxygen consumption (l/min), Ball Lift and Step Test.

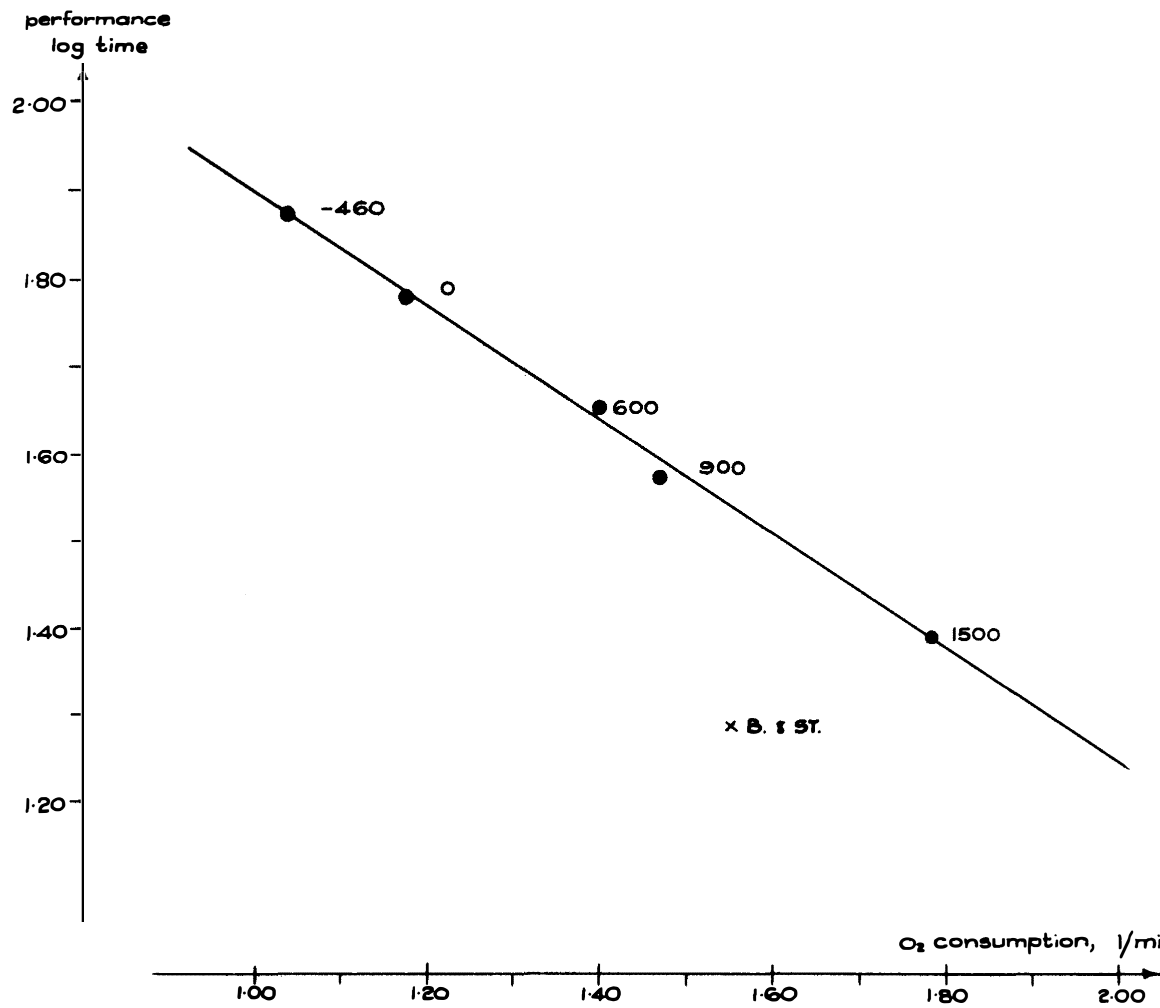


FIGURE 6

RELATIONSHIP BETWEEN PERFORMANCE AND O_2 CONSUMPTION ON 5 TRAMMING TASKS (EACH POINT ● REPRESENTING 60 PAIRS OF OBSERVATIONS) AND THE B. 1 ST. TEST (×, 100 OBSERVATIONS.)

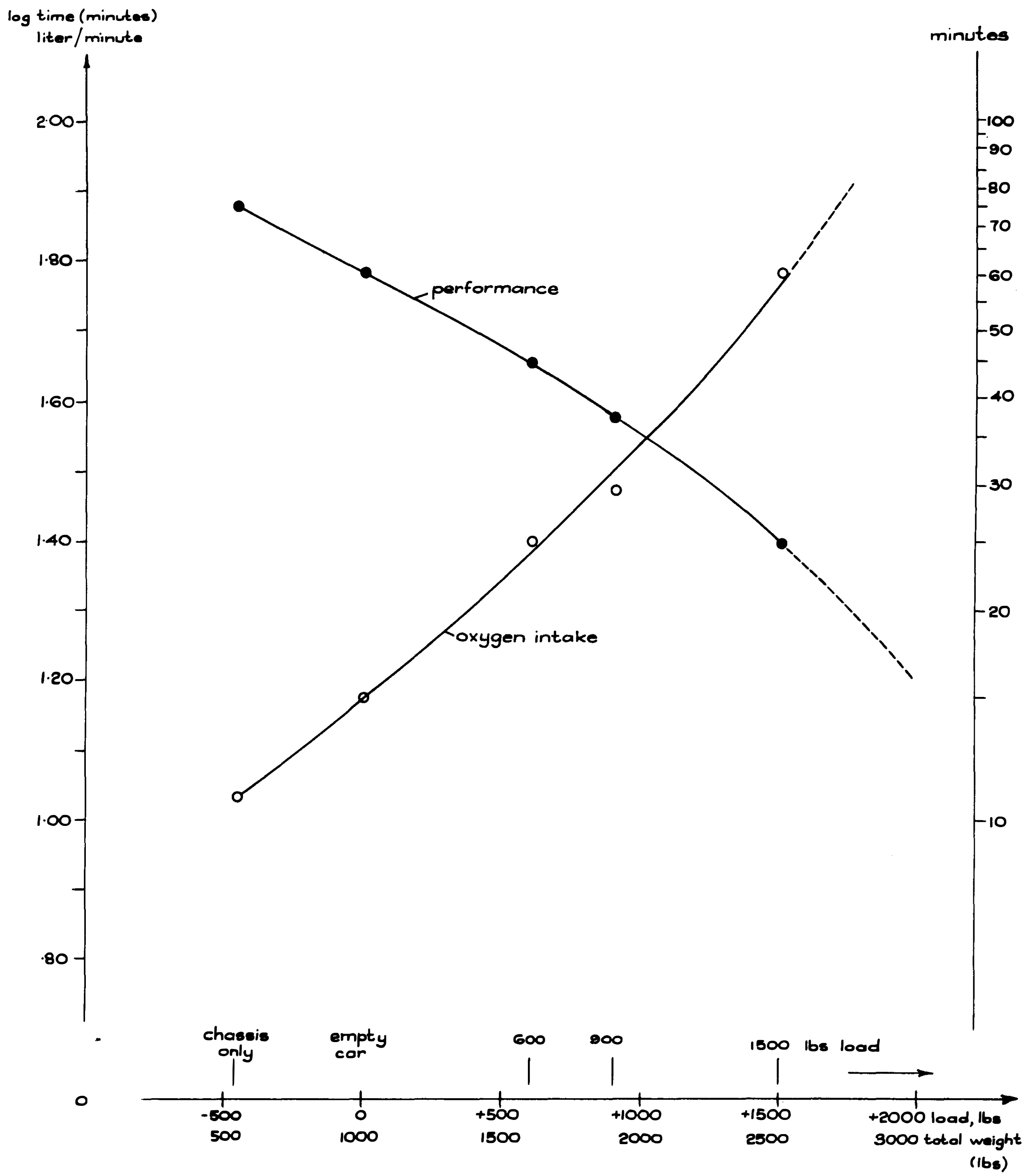


FIGURE 7

RELATIONSHIP OF PERFORMANCE (●) AND OXYGEN INTAKE (O) TO WORK LOAD IN TRAMMING ON A LEVEL TRACK.
EACH POINT OF THE CURVE REPRESENTS THE MEAN OF 60 OBSERVATIONS (6 TRIALS x 10 SUBJECTS.)

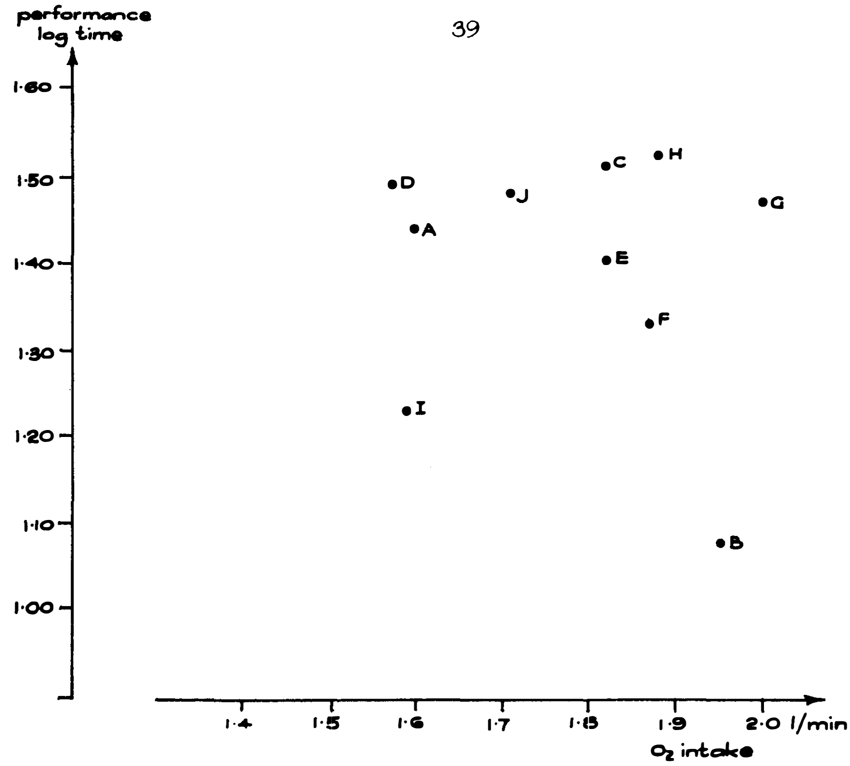


FIGURE 8a

BIVARIATE DISTRIBUTION OF PERFORMANCE AND OXYGEN INTAKE SCORES, TRAMMING 1500 LBS. EACH POINT REPRESENTS 1 SUBJECT'S AVERAGE SCORES OF 6 TRIALS.

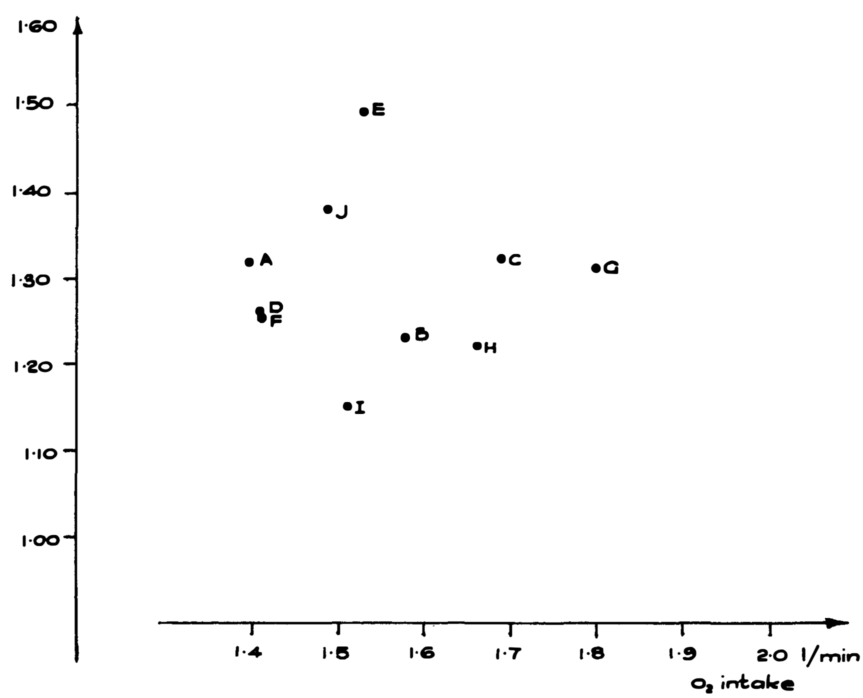


FIGURE 8b

BIVARIATE DISTRIBUTION OF PERFORMANCE AND OXYGEN INTAKE SCORES, B & ST TEST. EACH POINT REPRESENTS 1 SUBJECT'S AVERAGE SCORES OF 10 TRIALS.

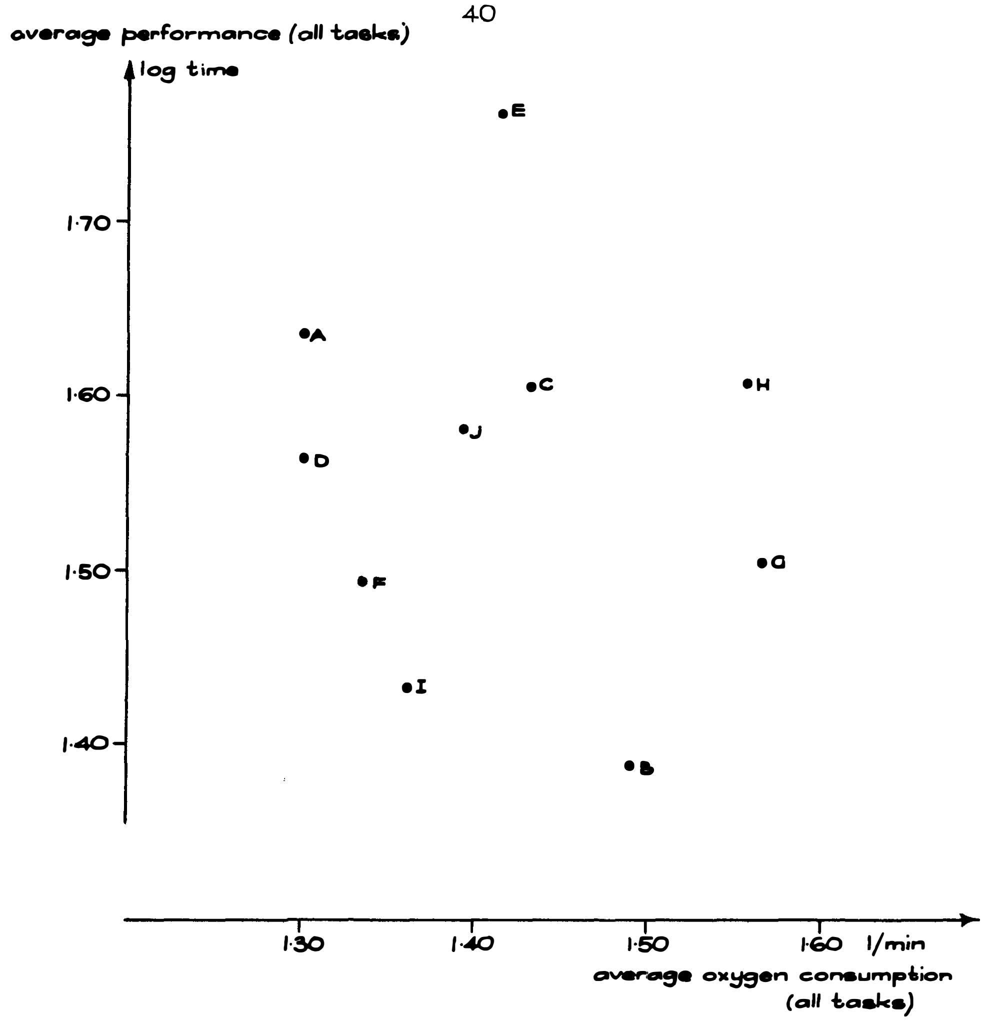


FIGURE 9a

BIVARIATE DISTRIBUTION OF PERFORMANCE AND OXYGEN INTAKE SCORES, ALL TASKS (MAIN EXP.) COMBINED.
EACH POINT REPRESENTS 1 SUBJECT'S AVERAGE SCORES OF 40 TRIALS ON 6 DIFFERENT TASKS (30 TRAMMING, 10 B & S.)

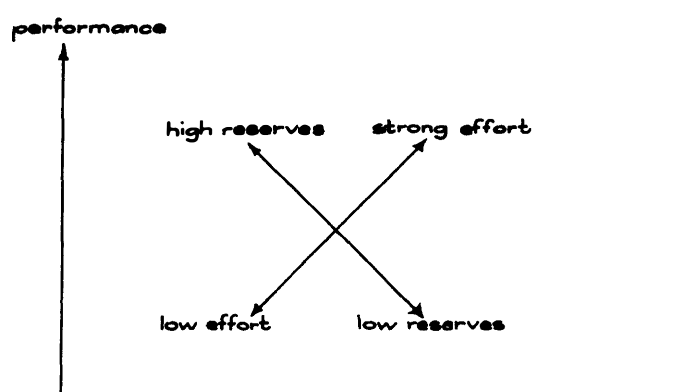


FIGURE 9b

SCHEMATIC REPRESENTATION OF COMBINATION SCORES, "EFFORT" AND "RESERVES" (SEE P. 16)

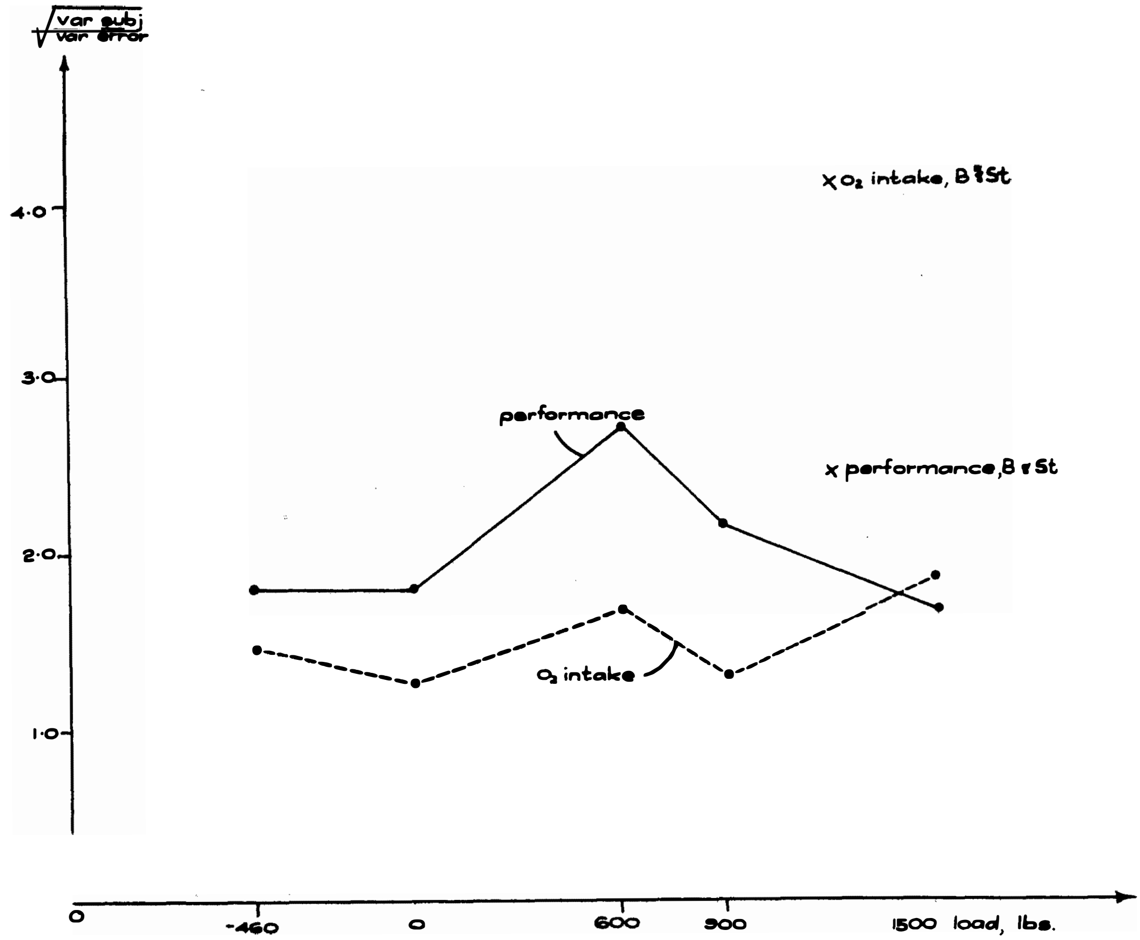


FIGURE 10

SQUARE ROOTS OF VARIANCE RATIOS (BETWEEN SUBJECTS/ERROR) OF PERFORMANCE AND OXYGEN INTAKE SCORES ON DIFFERENT TASKS.

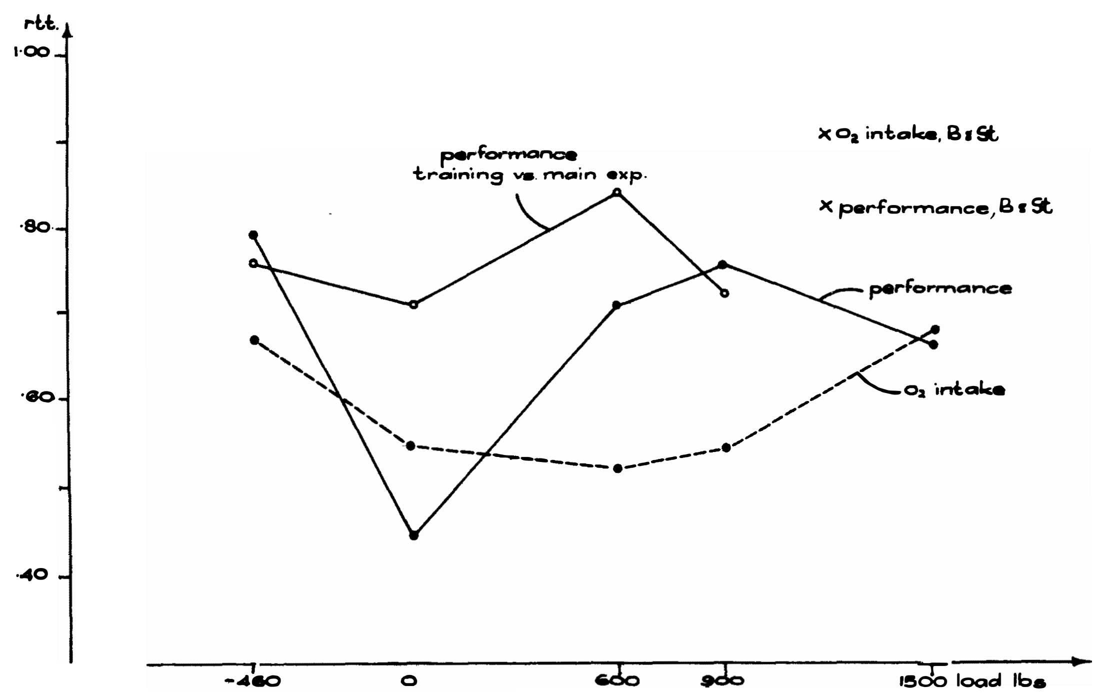


FIGURE 11

RELIABILITY COEFFICIENTS OF PERFORMANCE AND O_2 INTAKE SCORES ON DIFFERENT TASKS.

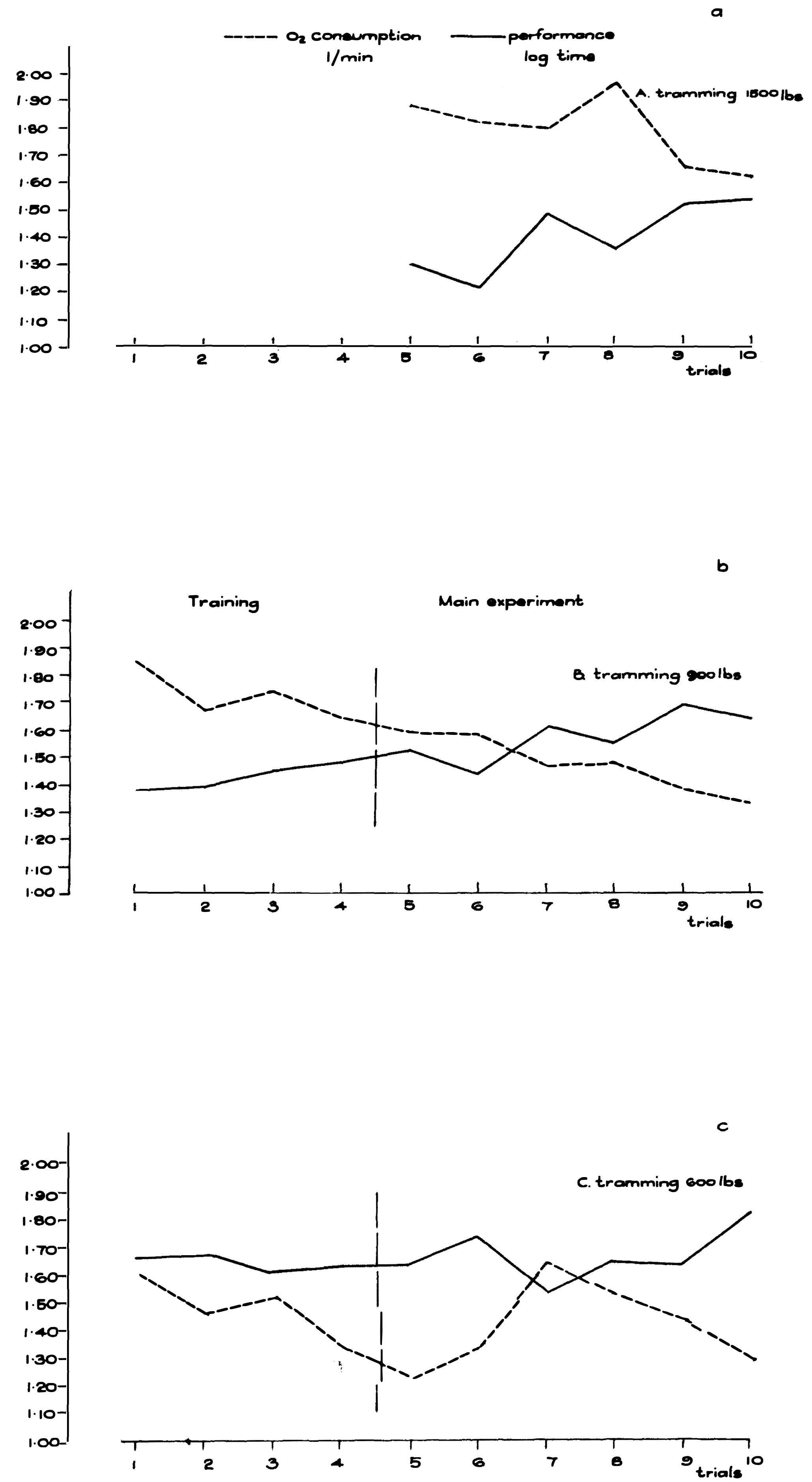
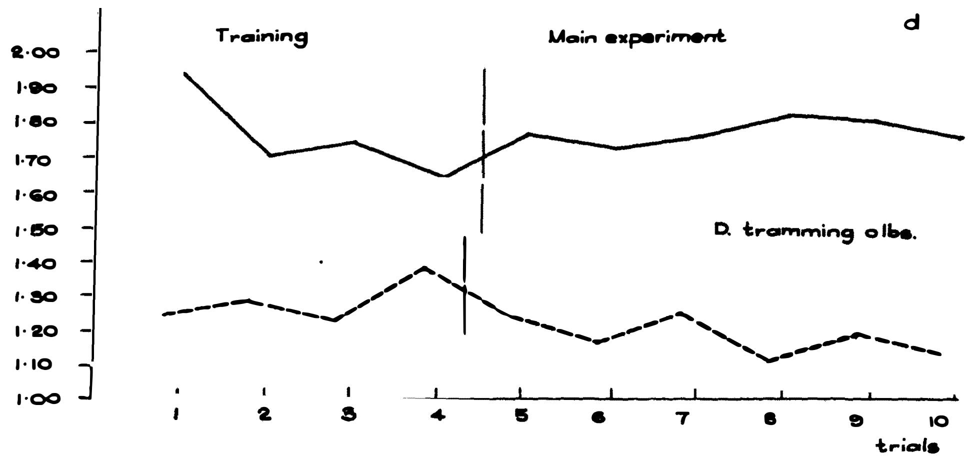
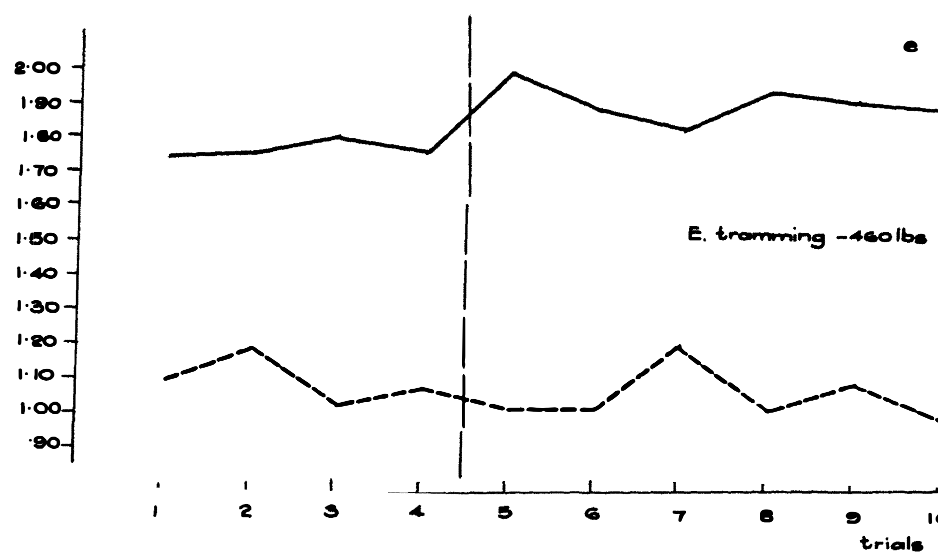


FIGURE 12
TRENDS OVER TRIALS





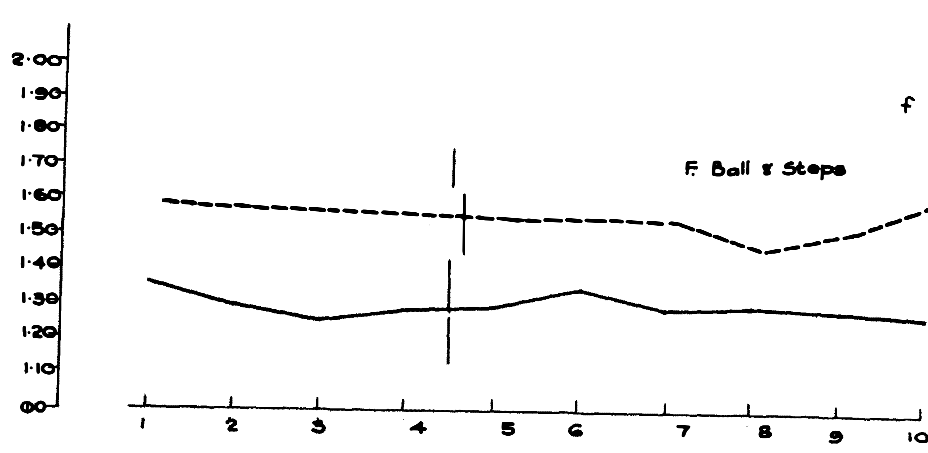


FIGURE 12 (CONTINUED)
TRENDS OVER TRIALS

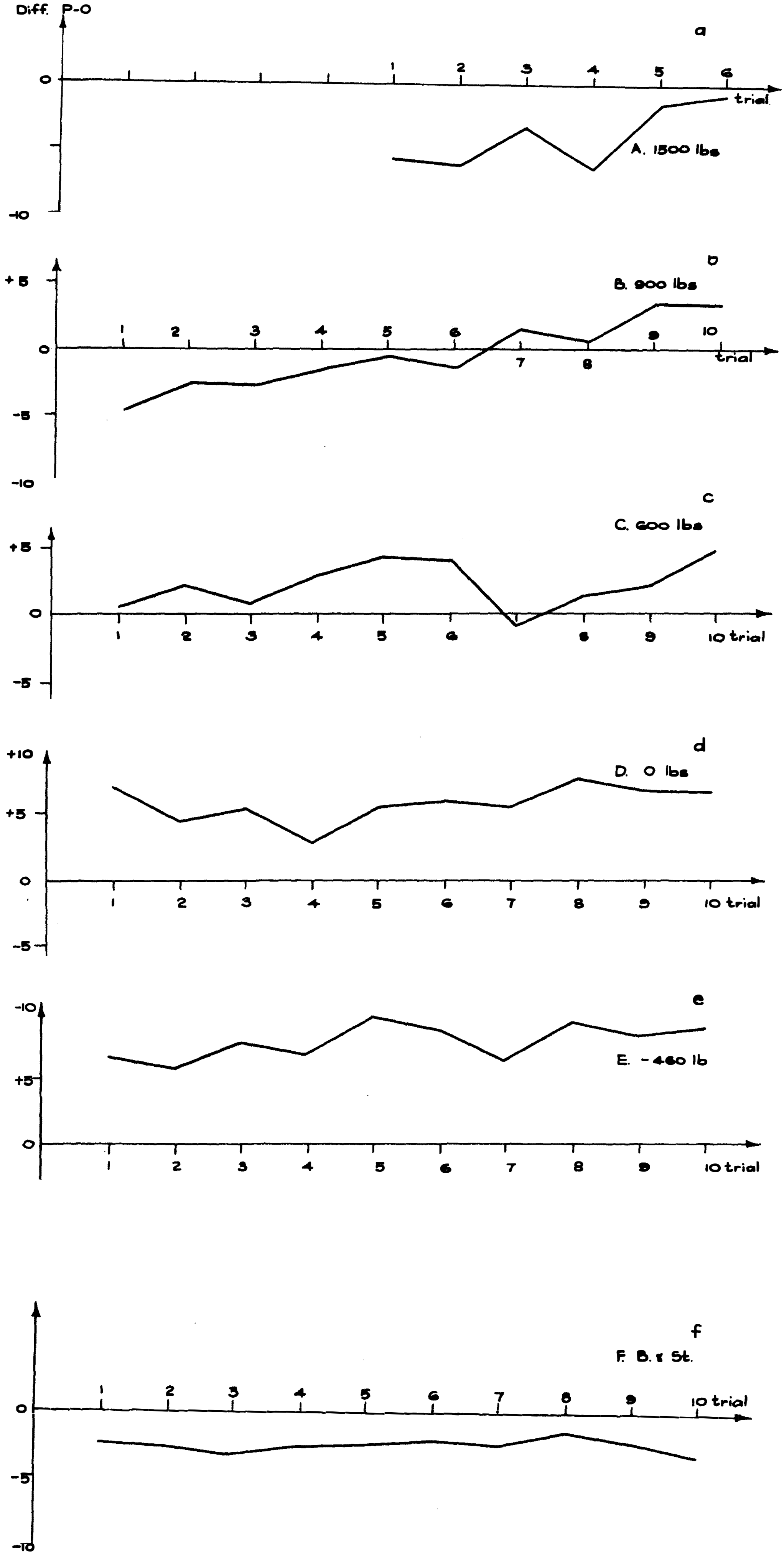


FIGURE 13
DIFFERENCES P-O ("RESERVES"), TRENDS OVER TRIALS.

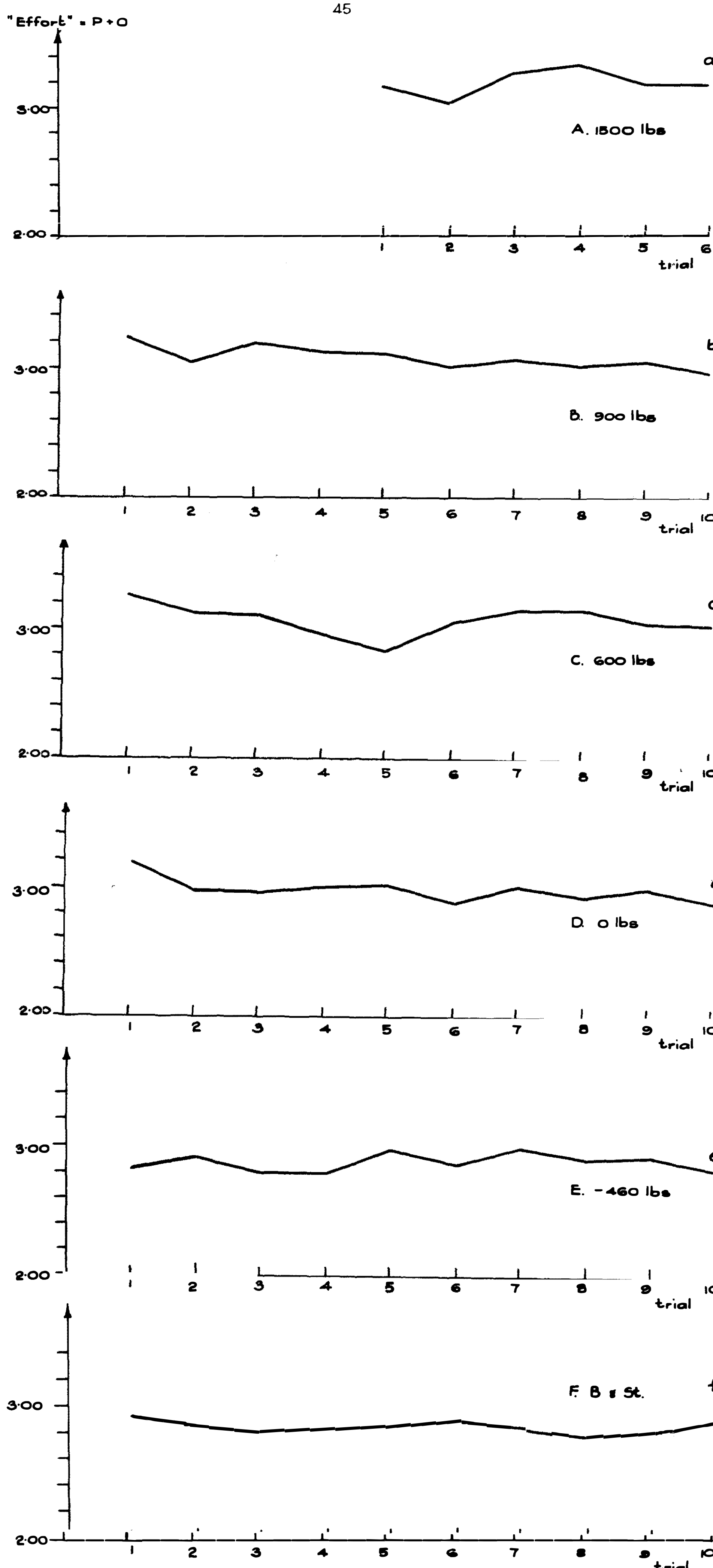


FIGURE 14
SUM P+O ("EFFORT"), TRENDS OVER TRIALS.

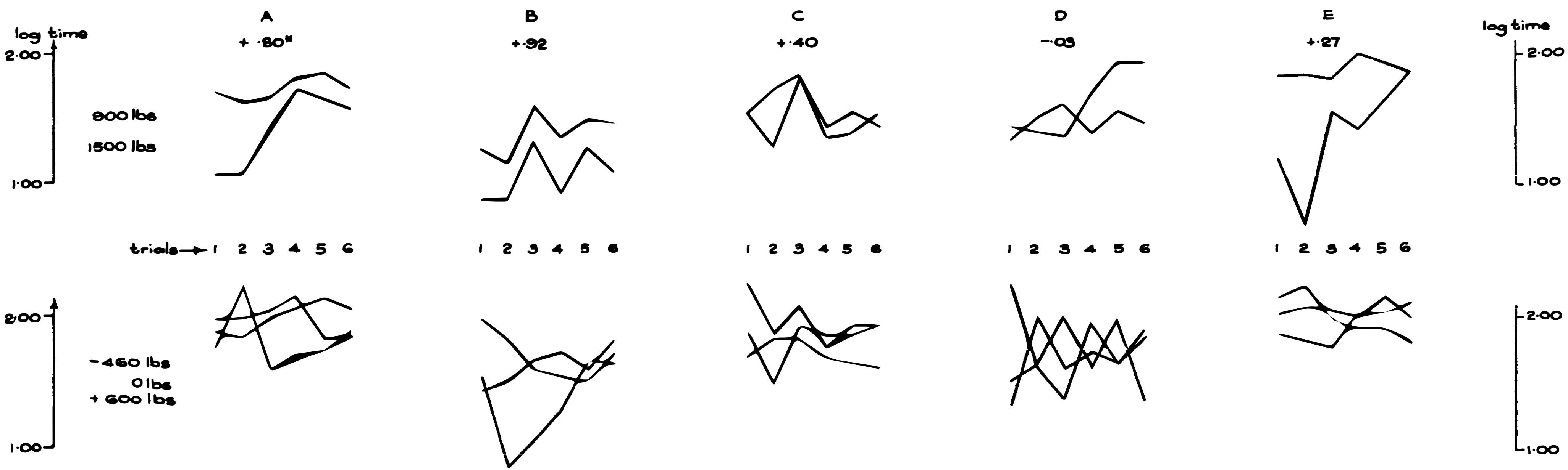


FIGURE 15

INDIVIDUAL TRENDS IN REPEATED TRAMMING PERFORMANCES. TEN INDIVIDUALS, A, B, ...J, EACH PERFORMING 6 TRIALS ON 5 DIFFERENT LOADS. UPPER TWO CURVES : HEAVIER LOADS; LOWER 3 CURVES : EASIER LOADS;
*THE FIGURES ABOVE THE CURVES ARE THE COEFFICIENTS OF CORRELATION BETWEEN THE TRENDS OF THE 2 HEAVY TASKS.

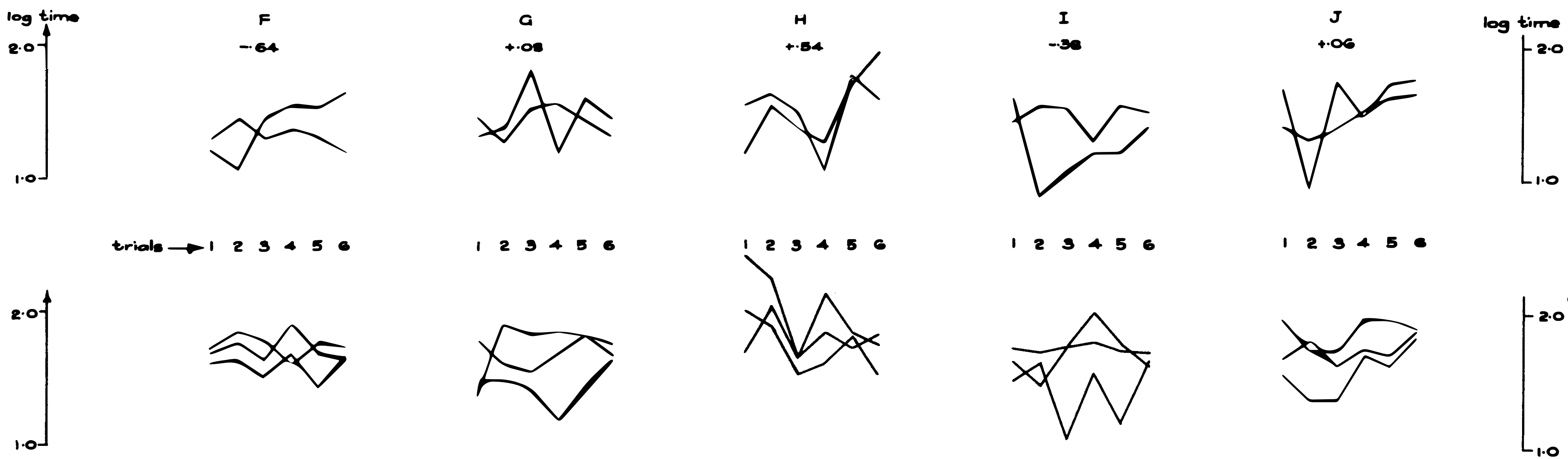


FIGURE 15 (CONTINUED)

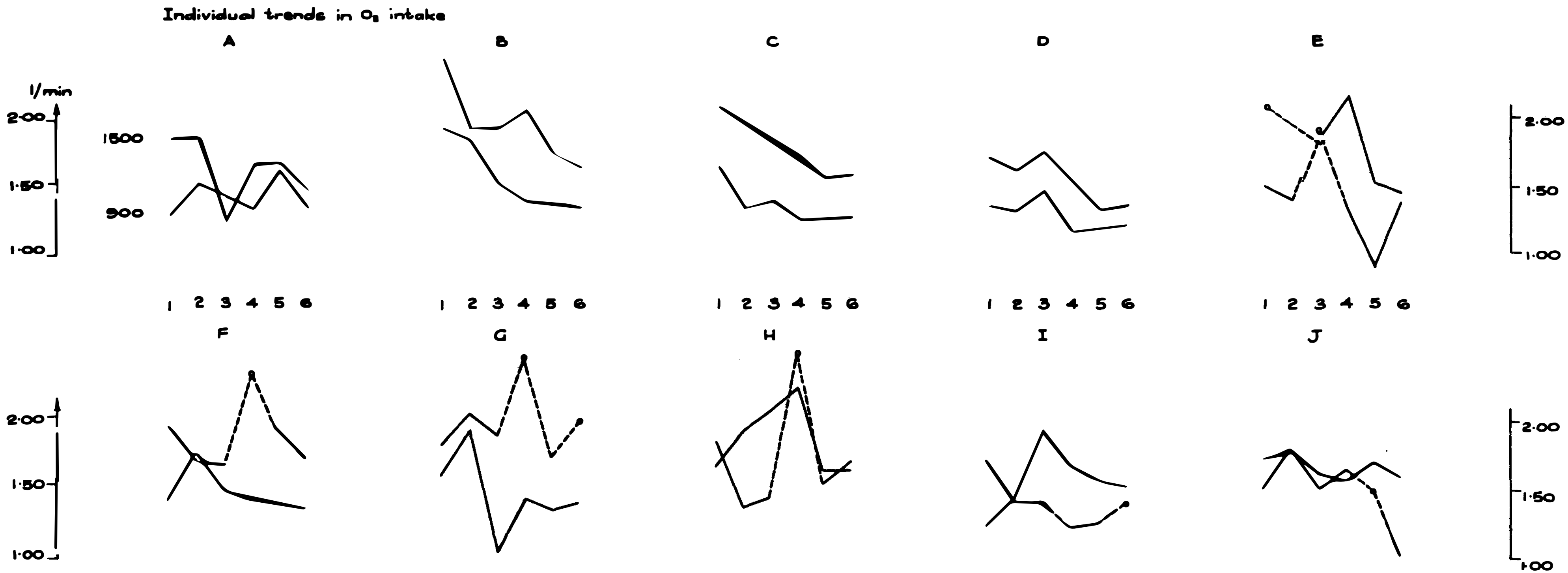


FIGURE 16

INDIVIDUAL TRENDS IN OXYGEN INTAKE FOR REPEATED TRAMMING TRIALS. INDIVIDUALS A, B, ····J, TRAMMING 1500 LBS (UPPER CURVE) AND 900 LBS (LOWER CURVE), 6 TRIALS EACH. (DOUBTFUL OR ESTIMATED SCORES ARE INDICATED BY CIRCLES AND BROKEN LINES.)

TABLE I

(a) Performance, log time, Tramming -460 lbs

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	2.21	1.92	1.82	1.75	1.63	1.69	1.46	1.66	1.56	1.67	1.74
2	1.81	1.66	1.81	1.99	1.85	1.50	1.66	1.87	1.55	1.76	1.75
3	1.79	1.66	2.06	1.89	2.02	1.46	1.84	1.83	1.47	1.81	1.78
4	1.95	1.56	1.86	1.61	1.93	1.62	1.73	1.77	1.65	1.72	1.74
Average, Training	1.94	1.70	1.89	1.81	1.86	1.57	1.67	1.78	1.56	1.74	1.752
Trial 5	1.90	1.99	2.26	2.24	2.02	1.73	1.48	2.44	1.65	1.97	1.97
6	1.86	1.86	1.89	1.61	2.08	1.87	1.92	2.27	1.48	1.73	1.86
7	2.00	1.60	2.09	1.40	2.05	1.81	1.85	1.69	1.77	1.72	1.80
8	2.09	1.56	1.78	1.96	2.01	1.62	1.87	2.17	2.02	1.98	1.91
9	2.15	1.52	1.94	1.66	2.16	1.80	1.85	1.88	1.79	1.98	1.87
10	2.07	1.73	1.94	1.92	2.00	1.76	(1.79)	1.78	1.63	1.90	1.85
Average, Main Exp.	2.01	1.71	1.98	1.80	2.05	1.76	1.79	2.04	1.72	1.88	1.876

(b) Oxygen consumption, liter/minute, Tramming -460 lbs.

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	1.04	1.05	.94	1.07	1.26	1.09	1.08	1.16	1.02	1.13	1.08
2	1.20	1.20	1.24	1.06	1.35	1.26	1.20	1.08	96	1.14	1.17
3	.95	1.00	1.10	.93	1.05	.89	1.17	1.13	.86	1.06	1.01
4	.98	1.03	1.17	.93	1.01	.95	1.14	1.13	1.17	1.04	1.06
Average, Training	1.04	1.07	1.11	1.00	1.17	1.05	1.15	1.12	1.00	1.09	1.0805
Trial 5	.58 ?	1.11	.99	.99	.99	1.03	1.27	1.16	.95	.93	1.00
6	.93	1.02	.96	.88	1.14	.97	.96	1.23	1.05	.90	1.00
7	1.50 ?	1.15	1.19	1.37?	1.06	1.13	1.08	1.10	1.24	.97	1.18
8	.94	1.10	1.07	.89	.98	.83	1.06	1.20	.95	.97	1.00
9	1.01	.95	(1.05)	.93	1.54	.84	1.14	1.32	.89	.96	1.06
10	1.04	1.04	1.03	.84	1.03	.57?	(1.10)	1.15	.89	.99	.97
Average, Main Exp.	1.00	1.06	1.05	.98	1.12	.90	1.10	1.19	1.00	.95	1.036

TABLE II

(a) Performance, log time, Tramming empty car (0 lbs)

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	2.09	1.86	2.22	1.94	2.19	1.63	2.01	2.11	1.56	1.81	1.94
2	1.94	1.75	1.89	1.76	1.83	1.39	1.46	1.84	1.39	1.81	1.71
3	1.94	1.76	1.75	1.87	1.73	1.62	1.51	1.81	1.74	1.72	1.74
4	1.99	1.75	1.68	1.46	2.01	1.50	1.45	1.39	(1.56)	1.64	1.64
Average Training	1.99	1.78	1.88	1.76	1.94	1.54	1.61	1.79	1.56	1.74	1.759
Trial 5	1.99	1.45	1.90	1.51	1.88	1.70	1.79	2.02	1.76	1.68	1.77
6	2.00	1.51	1.51	1.66	1.81	1.79	1.61	1.91	1.72	1.82	1.73
7	2.04	1.69	1.94	2.02	1.79	1.65	1.56	1.56	1.77	1.62	1.76
8	2.18	1.74	1.88	1.62	2.02	1.94	1.71	1.65	1.80	1.74	1.83
9	1.85	1.62	1.88	1.99	2.02	1.71	1.85	1.86	1.73	1.70	1.82
10	1.88	1.84	1.94	1.38	2.10	1.68	(1.70)	1.57	1.71	1.88	1.77
Average Main Exp.	1.99	1.64	1.84	1.70	1.94	1.74	1.70	1.76	1.75	1.74	1.7805

(b) Oxygen consumption, liter/minute, Tramming 0 lbs.

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	1.38	1.30	1.20	1.01	1.45	.73	1.39	1.28	1.49	1.24	1.25
2	1.31	1.20	1.32	1.11	1.30	1.27	1.56	1.26	1.12	1.31	1.28
3	1.30	1.30	1.28	1.08	1.27	1.05	1.37	1.16	1.13	1.26	1.22
4	1.22	1.26	1.65	1.36	1.16	1.22	1.90	1.54	1.12	1.21	1.36
Average Training	1.30	1.26	1.36	1.14	1.30	1.07	1.56	1.31	1.22	1.26	1.277
Trial 5	1.09	1.34	1.19	1.08	1.17	1.47	1.36	1.33	1.24	1.17	1.24
6	1.32	1.29	.75	1.07	1.24	1.16	1.35	1.23	1.05	1.10	1.16
7	1.12	1.17	1.19	1.01	1.41	1.12	1.15	1.90?	1.18	1.17	1.24
8	1.00	1.09	1.18	1.12	1.14	.98	1.22	1.27	1.12	.88	1.10
9	1.07	1.07	1.22	1.47	1.10	.95	1.23	(1.27)	1.02	1.42	1.18
10	1.03	1.14	1.18	1.05	1.20	.91	(1.26)	1.26	1.08	1.17	1.13
Average Main Exp.	1.10	1.18	1.12	1.13	1.21	1.10	1.26	1.38	1.12	1.15	1.175

TABLE III

(a) Performance, log time. Tramming 600 lbs

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	1.72	1.65	1.76	1.23	2.12	1.81	1.46	1.57	1.39	1.81	1.65
2	1.78	1.61	1.76	1.73	1.79	1.39	1.66	1.75	1.41	1.78	1.67
3	1.64	1.29	1.80	1.66	1.79	1.49	1.52	1.69	1.46	1.69	1.60
4	1.90	1.62	(1.77)	1.52	1.84	1.46	1.51	1.65	1.46	1.56	1.63
Average, Training	1.76	1.54	1.77	1.54	1.88	1.54	1.54	1.66	1.43	1.71	1.638
Trial 5	1.79	1.56	1.71	1.32	2.14	1.61	1.40	1.72	1.51	1.56	1.63
6	2.25	.90	1.85	2.00	2.22	1.65	1.40	2.06	1.64	1.38	1.74
7	1.61	1.08	1.85	1.62	1.98	1.52	1.46	1.69	1.08	1.38	1.53
8	1.73	1.30	1.69	1.73	1.92	1.70	1.20	1.88	1.57	1.70	1.64
9	1.76	1.70	1.66	1.66	1.93	1.46	1.48	1.76	1.20	1.61	1.62
10	1.91	1.66	1.62	1.86	1.82	1.69	1.66	1.87	1.66	1.82	1.76
Average, Main Exp.	1.84	1.37	1.73	1.70	2.00	1.60	1.43	1.83	1.44	1.58	1.6525

(b) Oxygen consumption, liter/minute, Tramming 600 lbs

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	1.55	1.60	1.74	1.57	1.49	1.52	1.51	1.60	1.74	1.70	1.60
2	1.42	1.27	1.57	1.53	1.49	1.41	1.49	1.41	1.48	1.48	1.46
3	1.57	1.66	1.56	1.36	1.53	1.93	1.30	1.39	1.35	1.45	1.51
4	1.29	1.16	(1.62)	1.32	1.55	1.25	1.39	1.29	1.33	1.42	1.36
Average, Training	1.46	1.42	1.62	1.44	1.52	1.53	1.42	1.42	1.48	1.51	1.482
Trial 5	1.16	1.28	1.29	1.20	1.18	1.12	1.09	1.26	1.25	1.29	1.21
6	1.06	(1.62)?	1.12	1.23	1.53	1.03	1.60	1.23	1.19	1.70	1.33
7	1.26	2.02	1.57	1.27	1.46	1.30	1.96	1.65	1.95	1.81	1.62
8	1.39	(1.56)?	1.56	1.26	1.30	1.50	2.08	1.67	1.50	1.36	1.52
9	1.39	(1.42)	1.38	1.78	1.15	1.33	1.50	1.35	1.47	1.45	1.42
10	(1.25)	1.35	1.29	1.22	1.37	1.17	1.49	1.34	1.14	1.22	1.28
Average, Main Exp.	1.25	1.54	1.37	1.33	1.33	1.24	1.62	1.42	1.42	1.47	1.399

TABLE IV

(a) Performance, log time, Tramming 900 lbs

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	1.32	.93	1.47	1.99	1.65	1.39	1.40	1.49	1.05	1.09	1.38
2	1.38	1.08	1.71	1.40	1.73	1.51	1.19	1.37	1.11	1.39	1.39
3	1.44	1.19	1.65	(1.62)	1.97	1.29	1.44	1.37	1.09	1.44	1.45
4	1.59	1.21	1.81	1.46	1.66	1.29	1.51	1.45	1.36	1.37	1.47
Average, Training	1.43	1.10	1.66	1.62	1.75	1.37	1.38	1.42	1.15	1.35	1.42
Trial 5	1.72	1.28	1.57	1.46	1.84	1.20	1.46	1.57	1.43	1.69	1.52
6	1.63	1.18	1.76	1.40	1.85	1.08	1.28	1.65	1.57	.95	1.44
7	1.67	1.62	1.85	1.38	1.82	1.46	1.53	1.52	1.56	1.75	1.62
8	1.83	1.38	1.46	1.72	2.00	1.57	1.57	1.08	1.30	1.49	1.54
9	1.89	1.51	1.57	1.94	1.94	1.53	1.46	1.80	1.57	1.72	1.69
10	1.77	1.49	1.46	1.94	1.88	1.66	1.32	1.61	1.52	1.76	1.64
Average, Main Exp.	1.75	1.41	1.61	1.64	1.89	1.42	1.44	1.54	1.49	1.56	1.5745

(b) Oxygen consumption, liter/minute, Tramming 900 lbs

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	2.23	2.24	1.74	1.43	1.66	1.57	2.11	1.85	1.93	1.78	1.85
2	1.97	1.44	1.83	1.65	1.74	1.65	1.28	1.92	1.59	1.64	1.67
3	1.80	2.00	1.54	1.48	1.81	1.73	1.79	1.87	1.71	1.68	1.74
4	1.81	1.65	1.53	1.44	1.77	1.61	1.61	1.61	1.71	1.68	1.64
Average, Training	1.95	1.83	1.66	1.50	1.74	1.64	1.70	1.81	1.74	1.70	1.727
Trial 5	1.28	1.92	1.65	1.37	1.50	1.41	1.61	1.87	1.74	1.55	1.59
6	1.50	1.85	1.34	1.33	1.40	1.76	1.93	1.39	1.43	1.84	1.58
7	1.41	1.51	1.40	1.48	1.92	1.47	1.03	1.46	(1.43)	1.55	1.47
8	1.31	1.39	1.26	1.19	1.33	1.40	1.43	2.50?	1.25	1.70	1.48
9	1.60	1.39	1.28	(1.32)	.91	1.37	1.37	1.56	1.27	(1.54)	1.36
10	1.32	1.36	1.28	1.22	1.38	1.34	1.41	1.72	(1.42)	1.06	1.35
Average, Main Exp.	1.40	1.57	1.37	1.32	1.41	1.46	1.46	1.75	1.42	1.54	1.470

TABLE V

(a) Performance, log time, Tramming 1500 lbs

(Main experiment only)

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	1.08	.90	1.57	1.36	1.20	1.30	1.32	1.20	1.61	1.40	1.29
2	1.08	.90	1.30	1.52	.70	1.46	1.38	1.56	.90	1.30	1.21
3	1.45	1.34	1.85	1.62	1.56	1.30	1.81	1.38	1.08	1.38	1.48
4	1.75	.95	1.38	1.40	1.43	1.38	1.20	1.28	1.20	1.52	1.35
5	1.69	1.30	1.40	1.57	1.65	1.32	1.62	1.73	1.20	1.62	1.51
6	1.60	1.11	1.56	1.48	1.88	1.20	(1.47)	1.97	1.40	1.65	1.53
Average, Main Exp.	1.44	1.08	1.51	1.49	1.40	1.33	1.47	1.52	1.23	1.48	1.395

(b) Oxygen consumption, liter/minute, Tramming 1500 lbs

(Main experiment only)

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	1.83	2.43	2.10	1.72	2.11	1.96	1.83	1.69	1.26	1.78	1.87
2	1.84	1.92	1.99	1.63	(1.82)	1.68	2.05	1.93	1.47	1.82	1.82
3	1.22	1.92	1.88	1.78	1.86	1.65	1.90	2.08	1.96	1.67	1.79
4	1.64	2.07	1.75	1.59	2.16	2.32	2.47	2.25	1.70	1.61	1.96
5	1.66	1.73	1.58	1.34	1.51	1.91	1.74	1.66	1.60	1.76	1.65
6	1.44	1.64	1.60	1.38	1.46	1.71	(2.00)	1.66	1.56	1.64	1.61
Average, Main Exp.	1.60	1.95	1.82	1.57	1.82	1.87	2.00	1.88	1.59	1.71	1.782

TABLE VI

(a) Performance, log time, Ball Lift and Step Test

(Training and Main Experiment combined)

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	1.41	1.37	1.34	1.33	1.51	1.32	1.51	1.18	.93	1.68	1.36
2	1.54	1.29	1.32	1.05	1.68	1.34	1.22	1.02	1.16	1.36	1.30
3	1.18	1.16	1.26	1.48	1.46	1.29	1.10	1.29	.93	1.37	1.25
4	1.19	1.25	1.42	1.33	1.42	1.25	1.18	1.26	1.18	1.31	1.28
5	1.27	1.06	1.26	1.21	1.48	1.23	1.55	1.09	1.34	1.45	1.29
6	1.26	1.16	1.46	1.27	1.56	1.61	1.37	1.17	1.21	1.36	1.34
7	1.31	1.29	1.35	1.11	1.39	1.20	1.34	1.25	1.21	1.37	1.28
8	1.30	1.31	1.26	1.29	1.49	1.08	1.39	1.30	1.24	1.29	1.30
9	1.44	1.30	1.39	1.26	1.50	1.12	1.12	1.32	1.04	1.31	1.28
10	1.30	1.15	1.13	1.28	1.45	1.13	(1.31)	1.36	1.26	1.25	1.26
Average	1.32	1.23	1.32	1.26	1.49	1.26	1.31	1.22	1.15	1.38	1.294

(b) Oxygen consumption, liter/minute, B & St. Test

(Training and Main Experiment combined)

Subject	A	B	C	D	E	F	G	H	I	J	Mean
Trial 1	1.44	1.52	1.83	1.49	1.59	1.45	1.80	1.67	1.64	1.56	1.60
2	1.49	1.61	1.67	1.49	1.57	1.57	1.64	1.56	1.68	1.51	1.58
3	1.44	1.64	1.66	1.47	1.54	1.46	1.83	1.64	1.51	1.50	1.57
4	1.36	1.63	1.80	1.46	1.60	1.60	1.62	1.51	1.46	1.49	1.55
5	1.56	1.58	1.67	1.40	1.53	1.38	1.96	1.65	1.36	1.39	1.55
6	1.64	1.61	1.66	1.47	1.49	1.35	1.85	1.56	1.46	1.38	1.55
7	1.40	1.62	1.65	1.40	1.53	1.46	1.89	1.67	1.34	1.49	1.54
8	1.18	1.49	1.63	1.08	1.60	1.07	1.76	1.72	1.57	1.43	1.45
9	1.17	1.50	1.66	1.41	1.30	1.43	1.85	1.68	1.46	1.53	1.50
10	1.36	1.65	1.69	1.44	1.56	1.36	(1.80)	1.90	1.64	1.59	1.60
Average	1.40	1.58	1.69	1.41	1.53	1.41	1.80	1.66	1.51	1.49	1.5489

TABLE VII

(a) Variance analyses, Performance, log time.

(b) Variance analyses, Oxygen Intake, liter/minute

			(a)					(b)				
Test task	Source of Variance	df	sums of squares	Variance	F ratio	P_F	Significance	sums of squares	Variance	F ratio	P_F	Significance
Tramming -460 lbs (chassis only)	Subjects	9	.9827	.1092	3.2024	< .005	v.s.*	.4198	.0466	2.1311	< .05	s.*
	Trials	5	.1639	.0328	.9615	> .30	n.s.	.2949	.0590	2.6946	< .05	s.
	error	45	1.5344	.0341				.9850	.0219			
	Total	59	2.6811	.0454				1.6997	.0288			
Tramming 0 lbs (empty car)	Subjects	9	.6514	.0724	3.2106	< .005	v.s.	.4161	.0462	1.5958	> .10	n.s.
	Trials	5	.0664	.0133	.5894	> .30	n.s.	.1749	.0350	1.2077	> .30	n.s.
	error	45	1.0144	.0225				1.3036	.0290			
	Total	59	1.7323	.0294				1.8946	.0321			
Tramming 600 lbs	Subjects	9	2.2744	.2527	7.2581	< .0005	v.s.	.7936	.0882	2.7080	< .025	s.
	Trials	5	.3494	.0699	2.0069	< .10	n.s.	1.1858	.2372	7.2837	< .0005	v.s.
	error	45	1.5668	.0348				1.4653	.0326			
	Total	59	4.1905	.0710				3.4447	.0584			
Tramming 900 lbs	Subjects	9	1.2894	.1433	4.5589	< .0005	v.s.	.8247	.0916	1.6844	> .10	n.s.
	Trials	5	.4359	.0872	2.7744	< .05	s.	.5194	.1039	1.9095	> .10	n.s.
	error	45	1.4141	.0314				2.4482	.0544			
	Total	59	3.1395	.0532				3.7923	.0643			
Tramming 1500 lbs	Subjects	9	1.0860	.1207	2.7210	< .025	s.	1.2715	.1413	3.3724	< .001	v.s.
	Trials	5	.8526	.1705	3.8450	< .01	v.s.	.8700	.1740	4.1536	< .005	v.s.
	error	45	1.9957	.0443				1.8852	.0419			
	Total	59	3.9343	.0667				4.0268	.0683			
Ball Lift and Step Test	Subjects	9	.7978	.0886	5.9936	< .0005	v.s.	1.5988	.1776	16.8853	< .0005	v.s.
	Trials	9	.0987	.0110	.7412	> .30	n.s.	.1747	.0194	1.8452	> .05	n.s.
	error	81	1.1980	.0148				.8522	.0105			
	Total	99	2.0945	.0212				2.6257	.0265			

* Abbreviations: v.s. = very significant

s. = significant

n.s. = not significant

TABLE VIII

RELIABILITY COEFFICIENTS

Test and Load	Performance		Oxygen Intake
	odd - even correlation	training vs. main	odd - even correlation
Tramming -460 lbs.	.791	.760	.664
" 0 lbs.	.443	.709	.543
" 600 lbs.	.702	.837	.521
" 900 lbs.	.747	.718	.541
" 1500 lbs.	.659	-	.674
Ball Lift & Step Test	.811	-	.903

TABLE IX

INTERCORRELATIONS

			Performance						Oxygen Intake						P + 0						P - 0					
			1500	900	600	0	-460	B&St	1500	900	600	0	-460	B&St	1500	900	600	0	-460	B&St	1500	900	600	0	-460	B&St
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	1500	1	-																							
	900	2	40	-																						
	600	3	57	86	-																					
Performance	0	4	35	84	79	-																				
	-460	5	64	76	90	78	-																			
	B&St	6	39	70	58	56	58	-																		
	1500	7	-14	-42	-23	-33	-05	11	-																	
	900	8	-07	-38	-08	-31	14	-24	49	-																
Oxygen	600	9	-19	-51	-64	-61	-36	-14	52	38	-															
Intake	0	10	25	-08	15	-18	34	-10	55	76	48	-														
	-460	11	17	20	30	11	50	11	47	48	41	86	-													
	B&St	12	17	-29	-22	-24	09	00	70	33	74	63	70	-												
	1500	13	62	-03	24	-01	43	38	69	34	28	62	50	68	-											
	900	14	34	68	78	58	85	51	-02	42	-20	52	58	-02	23	-										
P + 0	600	15	60	74	81	56	89	65	11	18	-07	57	71	28	52	87	-									
"Effort"	0	16	47	66	78	74	90	47	09	25	-19	53	68	22	42	85	87	-								
	-460	17	53	62	76	59	92	46	18	31	-07	62	80	38	52	85	94	93	-							
	B&St	18	36	17	15	12	41	57	64	13	52	51	64	82	78	27	60	46	57	-						
	1500	19	73	54	52	45	44	17	-78	-38	-48	-22	-21	-38	-08	23	31	23	21	-21	-					
	900	20	31	87	62	72	43	60	-54	-79	-54	-46	-12	-37	-20	24	39	31	25	04	57	-				
P - 0	600	21	47	80	95	79	76	46	-37	-21	-85	-09	04	-45	05	62	58	62	55	-11	55	65	-			
"Reserves"	0	22	11	65	48	82	36	41	-55	-66	-71	-70	-41	-54	-36	12	07	22	07	-20	45	78	62	-		
	-460	23	61	71	80	80	78	58	-39	-20	-71	-24	-16	-40	13	54	50	52	47	01	66	58	84	71	-	
	B&St	24	08	64	52	52	26	58	-15	-41	-68	-52	-50	-82	-34	31	14	09	-05	-34	40	64	63	67	66	-

Decimal points are omitted.

N = 10 ; df = 8

$r > .632$ significant 5%, } 2-tailed
$r > .765$ significant 1%, }

$r > .549$ significant 5%, } 1-tailed
$r > .716$ significant 1%, }

TABLE X

AVERAGE INTERCORRELATIONS

	Performance	Oxygen Intake	P + O	P - O
Performance	+.647	-.086	+.536	+.565
Oxygen Intake	-.086	+.567	+.368	-.453
P + O "Effort"	+.536	+.368	+.645	+.165
P - O "Reserves"	+.565	-.453	+.165	+.627

TABLE XI

VARIANCE ANALYSIS WITHIN INDIVIDUALS

			(a) Trends in Performance, log time					(b) Trends in Oxygen Intake, liter/minute				
Subject	Source of Variance	df	sums of squares	Variance	F ratio	P_F	Significance	sums of squares	Variance	F ratio	P_F	Significance
A	Trials	5	.171	.034	.971	> .30	n.s.*	.101	.020	.476	> .50	n.s.*
	Loads	4	1.279	.320	9.099	< .0005	v.s.	1.383	.346	8.150	< .0005	v.s.
	error	20	.703	.035				.848	.042			
	Total	29	2.152					2.332				
B	Trials	5	.282	.056	1.306	> .30	n.s.	.427	.085	2.381	< .10	s.?
	Loads	4	1.482	.371	8.575	< .0005	v.s.	2.974	.744	20.709	< .0005	v.s.
	error	20	.864	.043				.718	.036			
	Total	29	2.629					4.120				
C	Trials	5	.275	.055	2.944	< .05	s.	.199	.040	1.659	> .10	n.s.
	Loads	4	.833	.208	11.159	< .0005	v.s.	2.178	.544	22.732	< .0005	v.s.
	error	20	.373	.019				.479	.024			
	Total	29	1.482					2.855				
D	Trials	5	.122	.024	.369	> .50	n.s.	.219	.044	1.511	> .10	n.s.
	Loads	4	.303	.076	1.147	> .30	n.s.	1.190	.298	10.257	< .0005	v.s.
	error	20	1.322	.066				.580	.029			
	Total	29	1.748					1.990				
E	Trials	5	.155	.031	.669	> .50	n.s.	.280	.056	1.044	> .10	n.s.
	Loads	4	1.636	.409	8.804	< .0005	v.s.	1.748	.437	8.158	< .0005	v.s.
	error	20	.929	.046				1.072	.054			
	Total	29	2.720					3.100				
F	Trials	5	.052	.010	.537	> .50	n.s.	.237	.047	1.259	> .30	n.s.
	Loads	4	.916	.229	11.922	< .0005	v.s.	3.355	.839	22.289	< .0005	v.s.
	error	20	.384	.019				.753	.038			
	Total	29	1.351					4.344				
G	Trials	5	.124	.025	1.039	> .30	n.s.	.260	.052	.842	> .50	n.s.
	Loads	4	.688	.172	7.190	< .001	v.s.	2.874	.718	11.641	< .0005	v.s.
	error	20	.479	.024				1.234	.062			
	Total	29	1.291					4.368				
H	Trials	5	.378	.076	1.409	> .10	n.s.	.572	.114	2.042	> .10	n.s.
	Loads	4	1.120	.280	5.212	< .005	v.s.	1.915	.479	8.551	< .0005	v.s.
	error	20	1.074	.054				1.120	.056			
	Total	29	2.572					3.606				
I	Trials	5	.104	.021	.567	> .50	n.s.	.382	.076	2.465	< .10	s.?
	Loads	4	1.098	.275	7.499	< .001	v.s.	1.445	.361	11.669	< .005	v.s.
	error	20	.732	.037				.619	.031			
	Total	29	1.934					2.445				
J	Trials	5	.412	.082	3.600	< .025	s.	.231	.046	1.592	> .10	n.s.
	Loads	4	.625	.156	6.824	< .005	v.s.	2.270	.567	19.521	< .0005	v.s.
	error	20	.458	.023				.581	.029			
	Total	29	1.495					3.083				

* Abbreviations : v.s. = very significant
s. = significant
s.? = borderline significance
n.s. = not significant

APPENDIX

INSTRUCTIONS. TRAMMING

"You are all men. We have here a man's work to do. I am going to tell you and show you how to do it. This is very simple. I know you will all do it well. Listen very carefully.

These are the tracks. This is the ngolovan. I want you to push the ngolovan along these tracks. The clerk will tell you when to begin the job.

Once you begin you must not stop; keep on pushing the ngolovan, and go round and round, until you feel so tired that you cannot work any more. Then tell the lerk, and he will let you stop. Do not push the ngolovan too fast or too slow; keep the same speed all the time.

I will show you how to do the job. Hold the ngolovan here (demonstration) when you push it.

This is a clock (pointing to speedometer). It tells you how fast you must push the ngolovan. When you push it at the right speed this needle will point here (demonstration). Try and keep the needle at this point all the time. When you are too fast, the buzzer will sound (demonstration). When you are too slow, the bell will ring (demonstration).

Do not pay attention to the other men who are working; they are not doing the same work as you.

Now remember:

(i) Do not stop, keep on pushing the ngolovan.

(ii) Keep the same speed.

(iii) Tell the clerk when you are too tired to go on.

We want to see how long you can work. Try and work like men!"

APPENDIX CONTINUED

INSTRUCTIONS. BALL LIFT AND STEP TEST

"You are all men. We have here a man's work to do. I am going to tell you and show you how to do it. This job is very simple. I know you will all do it well. Listen very carefully.

This is a ball. This is the ball's box. These are the steps. These are the three holes. These are the lids; they open and close at different times like this (demonstration).

Your work is to take the ball from the box, walk up the steps, and drop the ball in this middle opening. Then go down the steps; take the ball again from the box, and drop it into the same middle opening. You must work so that, when you reach the top, the middle opening is opened. If you are too fast you will have to wait a bit before the middle opening opens. If you are too slow you will find the middle opening closed; in that case drop the ball in this hole (pointing) and quickly go down and bring the ball in time to find the middle opening opened before it closes again. So you see, you must always be in time to find the middle opening opened. If you do this, you are doing your work properly.

(Demonstration by tester,

(i) Reaching the top when middle opening opened.

(ii) Reaching the top when middle opening already closed).

Once you start you must not stop. Keep on working until you are very tired and you cannot work any more. Then tell the clerk and he will let you stop.

Watch the clerk; he will tell you when to start.

We want to see how long you can work. Try to work like men."

WNNR
CSIR