USE OF SCALING METHODS.

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USE OF SCALING METHODS IN PSYCHOPHYSIOLOGICAL ASSESSMENT OF PHYSICAL FATIGUE.

SPECIAL PROJECT

By

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Guide

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APPROVAL SHEET..

This special project entitled Use of Scaling Methods in Psychophysiological assessment of Physical Fatigue undertaken by Sunil c. Kolhe. Roll No. 856106 is approved for the partial fulfillment of the requirements for the Postgraduate Degree in Industrial Design.

Guide..

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INTRODUCTION...

There are two ordinary things in man s life that makes his heart beat faster .
1. Walking up the stairs and
2. Watching pretty girls.
The former reaction is mainly due to physical exertion while the later one due to psychological stress. Our interest here, however is solely focussing on psychological factors in the study of physical work such as problems concerning subjective estimatesof force perceived exertion and fatigue.

BEfore going for studying the use of scaling methods it in Psychophysiological Fatigue , it was felt necessary to know the concept of Fatigue.

Fatigue:
Physiologist often consider fatigue simply as a decrease in physical performance. Psychologist try to consider it as a condition affecting the mental process including factors such as feeling of fatigue, motivation and resulting deterioration of performance. Ergonomist and physicians lay stress on consequence of fatigue. In short it is redustion in the ability to do work because of previous work.

However fatigue may be viewed quite broadly in a context analogus to psychological activation theory i.e. that

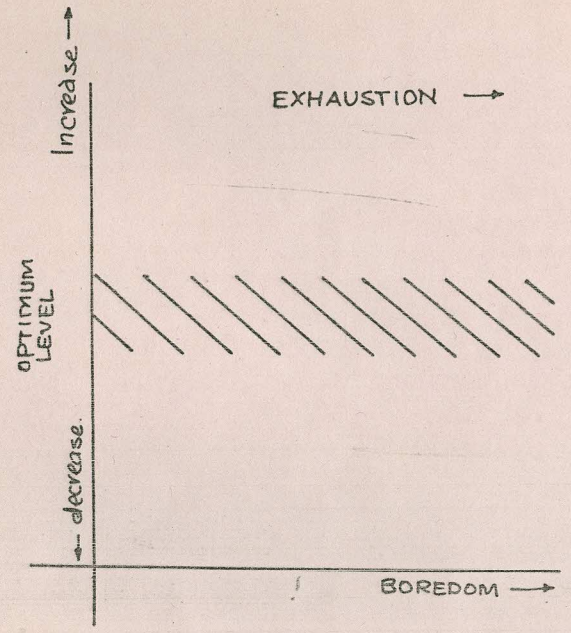


FIG : 1

people perform best at some optimum level of activation or difficulty.

Concept of Fatigue:

If a person is overloaded he suffers from an exhaustive type of fatigue. If he is insufficiently loaded he suffers from a type of fatigue known as Boredom or monetary. Fig. 1 indicates the concept of Fatigue.

Physiological measures aithough frequently used and relatively precise have not been systematically corelated with other behavioural measures. This is because the former one concerns primarily with physiological impairment of muscles while later one with subjective consideration which are also known to contribute to Fatigue. (KOlnicker/Tolcott 1962)

The subjective definition of Fatigue ...
An experienced self evaluation.... the avertion to activity.... the individual s assesment of his conditinn with reference to immediate work.

There exist a positive relationship between subjective estimation of fatigue and actual performance which has led to idea of using psychophysiological methods for determining fatigue criteria.

This is because the perception of exertion is an

indicator of degree of physicle strain and also an indirect indicator of physicle workin capacity.

Measurement of Physicle Strain.

Quantification of physicle strain/Fatigue can be ac achieved as...

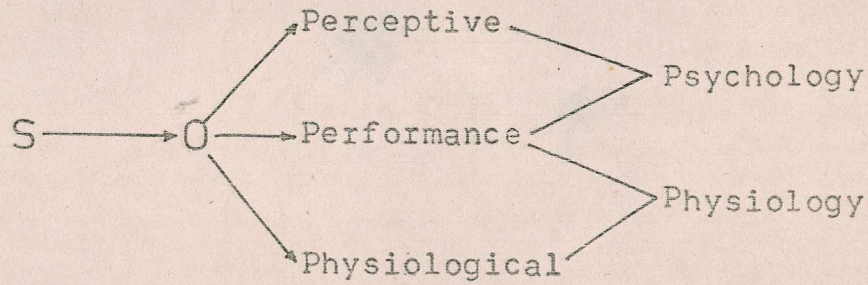
1. Physicle Measurements- such as Torque offer some information about physicle strain.
2. Physiological Measurements- such as heart rate, blood and muscle lactate, blood pressure, oxygen consumption, energy expenditure.
3. Psychological Variables-
   a. Perceptual.. working subjects' perceived exertion is often a measure as reliable as heart rate.
   b. Behavioural.. Heavy breathing, bodily movements sweating moaning.

In this paper we would be discussing mainly the Psychophysiological assessment of physical fatigue In that context the emphasis is given on that particular concept of fatigue.

In understanding of what happens in Central Nervous System when we are tired, one r3lates it to electrical rhythems or patterns from brain that can be observed on Electrocephalogram. The electrical Simulation of certain parts of brainscould make the person lethargic and sleepy (Hess,1927)

This inhibitory system in brain however is matched by what one might call an activating system based on reticular formation. ' A person's ability to perform is dependent on the degree of activity of these two systems. If the inhibitory system dominates the organism is in a stage of fatigue while if the activating system has the upper hand organism is ready to step up performance. this tends to explain the situation that are familiar to all of us,such as fatigue or tiredness that occures in monotonous or boring situation and sudden change or awakening that takes place when something new and int interesting or unexpected happens.

Thus the problem of fatigue is equally of psychological and physiological interest. It is a subjective state of a person with both of psychological and physiological aspect.



S - Stimulus situation
O - Observer.

Thus performance is classified as both physiological and psychological.

So to know the exact nature of physical stress both of it's indicators- Physiological and perceptual should be studied and analysed. Of these two, physiological indicators have got established way of analysing while psychological indicators such as perceived exertion is being studied with the help of psychophysical ratio scaling methods or category scales.

Ratio Scaling (Magnitude Estimation) offers the opportunity of obtaining ratios between intensities but they do not allo possibility of direct comparison between individuals unless some sort of cross modality is used. The Category scale on the other hand offers this possibility of interindividual comparison.

RATING SCALE:

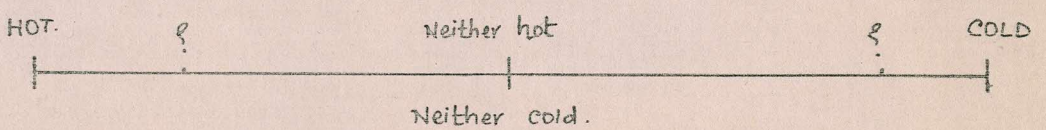
It is a method of subjective assessment which is quite extensively used in both psychological and ergonomics research investigations to give quantitative judgement of stimulus qualities. Typically in this dimension alongwhich stimulus attributes is to,be assessed is defined by means of suitable adjectives or phrases and assessor is required to indicate how far along the dimension stimulus should be placed.

2 differents forms of Rating scales exist in ergonomics research. 1) First type has a scale which presents to the accessor a straight line of fixed length with the defining adjectives or phrases placed at each end of the line. This type of scale normally called as 'Numerical' or linear. Anagur Rater have indicates how much along the line he considers the stimulus could fall with the distance of rating from one end.

2) Second type - (category ratio scale) rater is required to make his judgement by indicating which of a series of (usually 5/7) ordinally positioned adjectives best describes the stimulus qualifies under investigation.

Although simple to use and simple to analyse, both types of rating scales have their drawbacks.

1st Type: Major problem associated with the analogue scale related to the fact that unless the rating has been made at the extremes of the scale no meaning may be placed upon the rating.



IInd Type: Category rating scale of course does not suffer from this problem. Within the limits of scale one can be able to obtain from the rating, a description of the subjects assessment of the stimulus attribute. Its drawback however, less in the fact that the scale is only ordinal in character. Unless the scale has been carefully designed with the position of the categories being statistically determined, it would not be possible.

In addition the category scale does not allow the rater the ability to make any more than a cause assessment of the stimulus attribute.

The credit of studies and experiments which have gone into developing the psychophysical methods mainly goes to the G. Borg James Skinner Stevens et al. and first studies in this field dates back to 1958, initiated by G. Borg. These studies dealt with general psychophysical problems of subjective force and percived exertion and mere done with the aid of psychophysical ratio scaling methods. These methods functioned very well and enabled to describe the subjective force during short work periods (less than one min.) on a bycycle ergometer and also the perceived exertion or fatigue during most of longer duration (general minutes) with power function with an exponent of 1.6.

For adopting the work intensity to a subject this non-linearity must be kept in mind. Heart rate increases

linearly with work load but the perceived exertion similar to lactic acid concentration rises according to a positively accelerating function, which could be described by the following expression

$$R = a + C.S^n$$

where,

R = subjective force
a = basic perceptual noise
C = measure constant
S = power in kgm/min
n = power exponent found to be 1.6.

In many different areas of physical work the subjective intensity grows according to a positively accelerated function with the physical working load.

e.g. handgrip force n = 1.7
isometric by force n = 1.6
weight lifting n = 1.45

This ratio scaling method yielded only ratios between percepts and no direct levels for inter individual comparisons. To solve this problem G. Borg used the range of work intensities perceived as a frame of reference for interindividual comparisons.

To solve for the measurement constant 'C' for each individual it was assumed that the subjective range from a basic perceptual noise level to a maximum intensity level is a stimulus range (the performance range) from zero to a maximal intensity is different.

$$C = \frac{R_t - a}{S_t^n}$$

t stands for terminal (maximal) values.

where, $(R_t - a)$ is equal for all subjects and S_t and n may be determined empirically for each individual.

This model for interindividual comparisons was in later studies validated by using a physiological variable in the form of heart rate as a validity criteria.

A SIMPLE RATING SCALE:

The model for interindividual comparisons did not however, help much in the applied studies. A very simple method was needed that could be used by nearly every one.

After some trial and error Borg devised a twenty one point graded category scale.

The ratings according to the scale gave high co-relation with heart rate e.g. in groups of healthy people correlation

6	
7	VERY VERY LIGHT.
8	
9	VERY LIGHT
10	
11	FAIRLY LIGHT
12	
13	SOMEWHAT HARD
14	
15	HARD
16	
17	VERY HARD
18	
19	VERY VERY HARD.
20	

FIG : 2.

between 0.8 and 0.9 if the work intensity was varied from light to heavy work.

Scale was from very very hight to very very hard work.

To increase the linearity between the ratings and the work load (and the heart rate) the scale was later changed to 15 point graded category scale and is as follow from 6 to 20. FIG: 2

The RPE values follow the heart rate very closely for healthy middleaged man doing moderate hard work on a bycycle ergometer or treademill the heart rate should be about 40 times the RPE values.

This RPE scale is founded on Borg's proposed range theory. Briefly this theory states that all healthy individuals perceive roughly the same degree of exertion while performing dynamic work at their respective maximal physical capacity. It also follows that all individuals experience about the same degree of exertion while marking at the same percentage of their respective maximal physical capacity.

This scale is constructed to obtain the linear relation between ratings and work loads and since pulse rate rises linearly with work load also between rating and pulse rate! The correlation between pulse rate and rating of 0.80 to 0.90 have been found out. (Berg Skinner et al.).

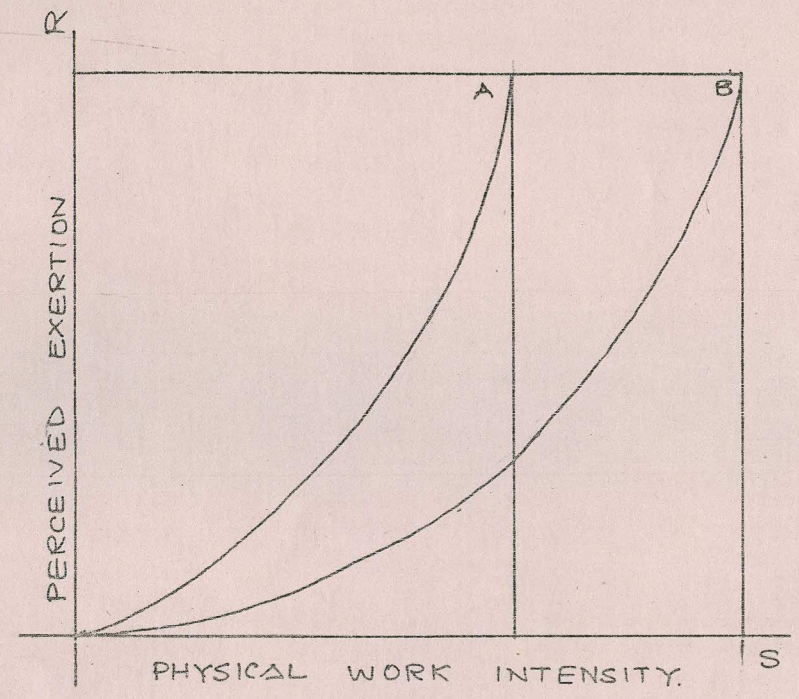


FIG · 3

RELATION BETWEEN PE AND PHYSICAL WORK INTENSITY FOR TWO INDIVIDUALS A & B WITH DIFFERENT MAXIMAL PERFORMANCE LEVEL.

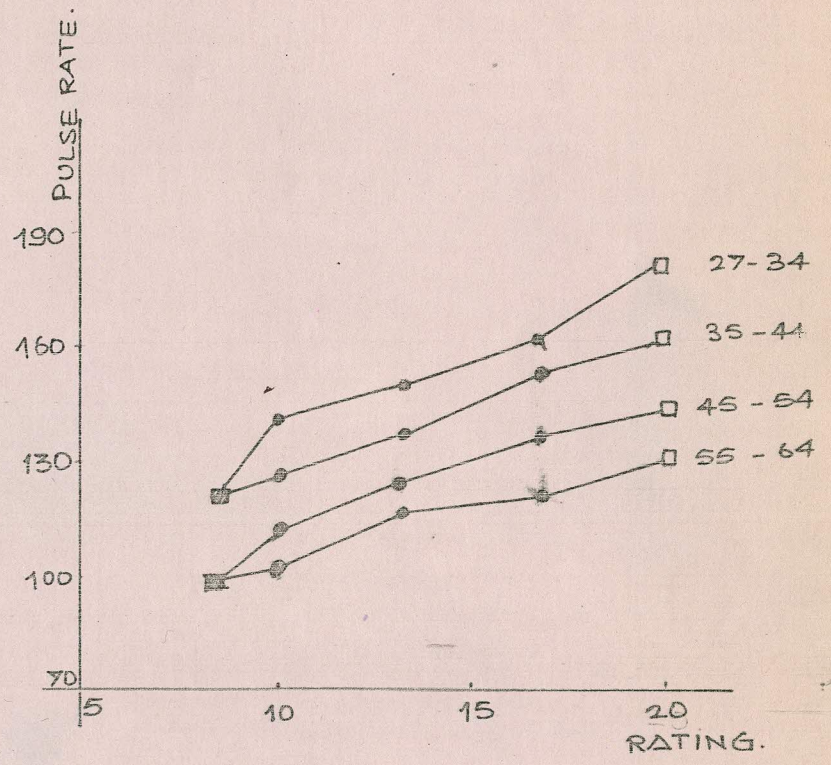
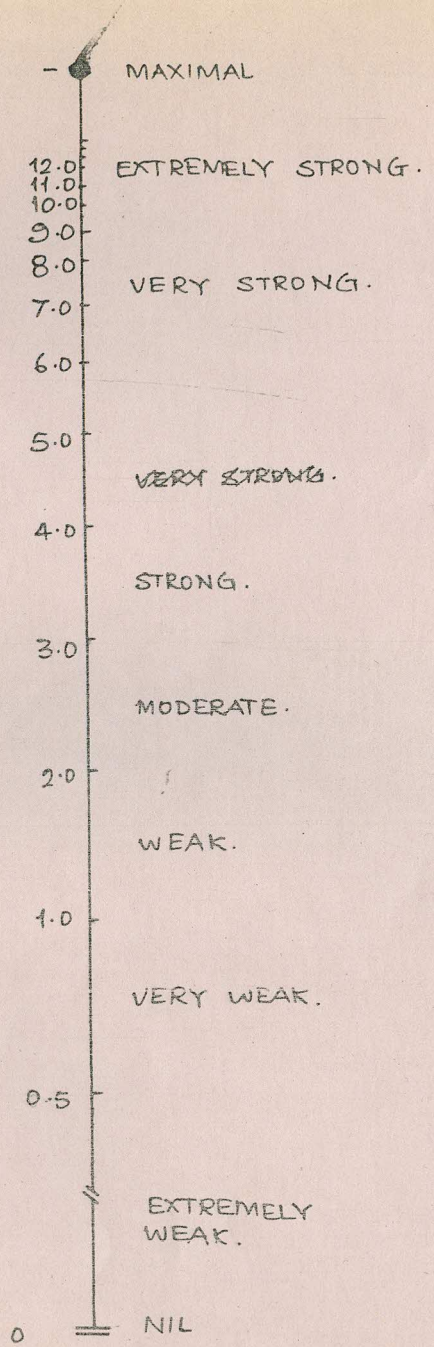


FIG. 4.



FIG·5

The relation between ratings of perceived exertion and heart rate changes with age and also with pathological conditions. Fig. 4 shows pulserate - rating relation for four different age groups.

The older subjects rate the degree of exertion to be higher in relation to heart rate than do the younger subjects. This age change with age seems mainly to depend upon the decrease of the maximal heart rate with age.

In a study of patients with vaso regulatory asthenia it was found that they gave lower ratings in relation to heart rate than a healthy control group. In patients with coronary heart desease there is opposite reaction flowever in all patients the increase of ratings of perceived exertion is greater in relation to the increase of heart rate.

Category ratio scale CR-12 (Borg 1982) — FIG. 5

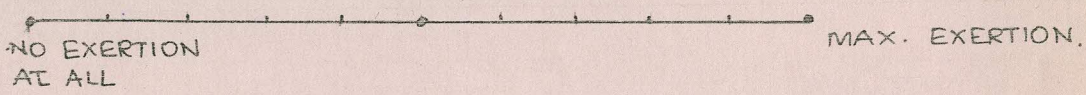
This scale is also founded on Borg's proposed 'range theory' explained earlier. This scale is anchored at the lower end by the verbal expression 'Nothing at all' and with the no. '0' and at the top by the verbal label Maximal although no number is designated for this label. According to the instructions the exertion as strong as ever experienced before corresponds to extremely strong i.e. the number 12. If however, by chance an even stronger exertion than ever before is experienced, the subject can use a corres-

pondingly still higher number. This is why the top label has no number designated but should correspond to an individually chosen number. This free choice of numbers is also indicated by the gap below the label 'Maximal'. The subject is free to use decimals through out the scale.

The scale is constructed in order to obtain ratings largly on the 'ratio level' i.e. with absolute 0 point and equidistant scale steps.

Some more rating methods:

1) A line Scale:



It is a 11 point scale to the left of which is written 'no exertion at all' and to the write Maximal exertion at all'

The subject mark the intensity of perception of exertion on the above line.

2) A 9 point graded seal:-

The number 2 in above scale is anchored with the expression

'not at all stressful', and number 8 with the expression ' very very stressful'.

3) A 5 point graded scale (Grandjean)

1 - No discomfort

5 - Very severe discomfort.

4) A 7 point graded scale (Shwartz 1980)

1 - extreme discomfrot
7 - extreme comfort.

5) 3 point scale : (Grandjean)

Uncomfortable
Medium
Comfortable.

Comparison of some rating methods:

G. Borg carried out 2 experiments where either the time duration or work load was changed. In both the experiments the rating methods used were

1) RPE scale
2) Old 21 pt graded scale
3) 11 pt. scale
4) g pt scale.

These experiments indicated good correlation between heart rate and perceived exertion rating independent of scale used. There exists obviously a fundamental relationship between a physiological indicator of physical stress such as heart rate and a psychological indicator such as rating of per exertion.

Since the RPR scale gives the values that grow linearly with workload/heartrate etc. and since no other scale seems to give better correlation with heart rate. It is proposed that RPR scale should be used in most of the cases.

The linear increase of the RPR values with work load (hR) makes it simple to use and makes if easy to perform intra-extrapolations. The true variation of p.e. follows however, a positively accelerated function with an exponent about I.6.

In some instances it is thus better to use a ratio sealing method for e.g. as a magnitude estimation. This is necessary when we went to study function forms, how the pr grows with physical intensity and when we want to compare such functions with those obtained for other modalities or when we want to compare such functions with those obtained for other modalities or when we want to explain the psycho-physical functions by looking at corresponding physiological ones.

In most applied situations however, when we want to make simple level comparisons between various work tasks or between individuals the category methods are very useful and better than ratio scaling methods.

APPLICATIONS OF SCALING METHODS:

In evaluating physiological stress perceived by the subject during brooming activities in a Indian kitchen 3 different scales were used. Different scales to rate physical or psychological parameters and were as follows.

Fatigue:

0. Nothing what soever
1. Faintly tired
2. Fairly tired
3. Tired
4. Very tired
5. Extremely tired (Maximal)

Joint/Body Pain and Ache:

0. Nil
1. Slightly
2. Fairly light
3. Neither light nor strong
4. Strong
5. Very prohouneed.

Task Rating:

1. Very light
2. Fairly light
3. Moderately heavy

4. Heavy
5. Very heavy.

The experiments were carried out on 3 different subjects with differents kinds of brooms, and were conducted by (Dr. Ray, Mrs. Chaterjee et al.).

Hindustan Brown Bovery:

Assemble basically the PCBS and transformers.

Tasks in PCB assembling.

2 In the group of either of these the boards are
4 put on the table (All in the group are same).
8

The parts to be mounted on them are

1) Resistances
2) Capacitors
3) Inductances
4) Capacitances
5) Transistors

and things like that.

The assembling goes as follows:

1) Observing the standard circuit on the paper, the operator selects a point from where to start. Then from there either up or sidewards he/she progresses. In these cases

he wants the piece selected on all boards. The pattern of progressing from one board to another and so on also gets somewhat settled or standardised for that particular person.

Activities in sequence would be:

1) Identify the where to mount.
2) What to mount
3) Crosscheck from paper to board
4) Identifying the right piece from the table storage.
5) Mounting this piece for the board.
6) Shifting from one board to other.

While mounting on the other boards, the operator tends to rest his elbows on the front boards.

Areas of pain-ache in the body would be

1) Fingers
2) Shoulder joint
3) Eyes.

There would be physiological fatigue in the case of fingers and shoulder experienced by operator.

While in the case of eyes the fatigue goes more towards the psychological aspect of it. The reason would be because all the analysing and observing is controlled by mental condition and because of repetitite work/monetory (visual fatigue).

Transformer Winding - Involves the winding of the wires of different sizes depending on the capacity of transformer. The operation is carried out on coil winding
1) Manual 2) Automatic. In the manual the turns of the wire are counted by operator and then accordingly the m/c is controlled. While in automatic one the machine itself counts and gets controlled.

Parts - ON THE M/C

Adjust the turns
Count them
Apply the brakes
Off the machine

The brakes are pedal operated.

The body parts involved in the activity are

1) Eyes - to count/observe with display the tuns
2) Foot- to apply brakes
3) Finger/wrist - on/off machine
4) Palm/elbow forearm - controlling the wire.

In both of these tasks - the workload is more which would contribute to physilogical fatigue. But the monetary of work is such that it gives the operator the great amount of psychological fatigue.

So the exertion which operator perceives is greater even though the physiological exertion would be less.

In this regard the scaling methods would play important role since they would contribute to psychophysiological assessment of fatigue.

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