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REVIEW ARTICLE

THE USE OF RATING SCALES IN PSYCHOPHYSICAL RESEARCH: A SHORT REVIEW

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ABSTRACT

One of the major and continuing debates among perceptual psychologists and physiologists relates to the preferred method to employ in obtaining psychophysical judgements. One of the difficulties in assessing subjective reactions to work is that, as a privately experienced sensation, perceived exertion can only be measured indirectly through the use of self-report techniques. Several techniques, (e.g., ratio scaling and category scaling) are available to researchers, but each method has inherent advantages and limitations. In some cases, ratio-scaling techniques are more appropriate, as when evaluating the growth of subjective sensations with increasing stimulus intensity. On the other hand, when there is a need to make comparisons between work tasks or between individuals, particularly in clinical and applied settings, the category methods are preferable. There is however general agreement that the Borg scale should be used in most cases, as it has shown versatility, parsimony and validity.

Key words: Perceived exertion; Rating scales.

One of the major and continuing debates among perceptual psychologists and physiologists relates to the preferred method to employ in obtaining psychophysical judgements. As a basis for criteria in the assessment of human movement, subjective reactions have not until recently been seriously considered. The reason for this neglect in favour of the more readily definable physiological indicators is that these reactions have been difficult to define and measure (Gamberale, 1985). These fundamental difficulties are connected with the nature of the measurement itself. As a privately experienced event or sensation, perceived exertion can only be measured indirectly through the use of self-report techniques. This self-report thus only constitutes a distal reaction, and the extent to which this is a reflection of the proximal reaction (i.e. the reaction within the individual organism) relies very heavily on the adequacy of the measurement tool or procedure adopted. The applicability of subjective symptoms as criteria in the assessment of human movement will depend on factors affecting validity and reliability.

These include how well the reaction correlates with work intensity and performance, and how well it correlates with the physiological and neurological events (Gamberale, 1985).

Borg (1962) originally investigated the growth of perceived exertion with increasing intensity using ratio-scaling procedures before adopting a category-rating scale. Today considerable controversy still exists regarding the efficacy of ratio and category-scaling procedures for psychophysical measurement. This paper examines the advantages and disadvantages of both, and in so doing aims to provide some clarity on the issue, thereby enabling researchers to determine the method best suited to answer the questions posed by their particular studies.

Ratio-scaling Techniques

For most sensory and perceptual dimensions, the functional relationship between subjective sensory or perceptual magnitude and the physical dimension being manipulated appears to approximate a power function (Borg, 1973; 1982; Gamberale, 1985). Power functions thus describe the perceptual variation with physical intensity. The expression of such a power function in logarithmic terms results in a simple linear equation which, when plotted on log-log coordinates, constitutes a straight line. An exponent of greater than 1.0 indicates that the perceptual intensity is a positively accelerated function of the physical stimulus, while an exponent of less than 1.0 indicates that the function is negatively accelerated.

Various direct ratio-scaling methods have been used in psychophysical studies. One such method is *ratio-production*, in which subjects are asked to increase or decrease a certain variable stimulus until it is perceived to be a certain fraction or multiple of a standard stimulus (Borg, 1982). Put another way, the subject manipulates the physical stimuli to reflect a given subjective reaction. Generally, however, estimation methods such as *magnitude* estimation have been preferred in the study of perceptions of physical work (Mihevic, 1983). With this method, subjects are presented stimuli of different intensities and are asked to assign numbers to them in proportion to the perceived magnitude of each stimulus (Borg, 1982). As stated earlier, greater perceptual sensitivity is reflected in a higher perceptual exponent. For both of these direct-scaling methods, the basic assumption is that subjects are able to match perceptions with numbers. Studies have supported the validity of this assumption, and the result is that the subjective scale obtained is a ratio scale (Gamberale, 1985).

The positively accelerated ratio of perceived exertion (RPE) work load

relationship identified by ratio-scaling is consonant with expectations derived from classical pyschophysical theory (Morgan, 1981). Why then has this procedure not been universally adopted? Before answering this question, there is a need to examine the merits of category scaling techniques.

Category-scaling Techniques

To overcome the difficulties involved in ratio-scaling, Borg (1962) developed a 21 grade rating scale to determine perceived exertion, the odd numbers of this scale being anchored with verbal expressions. This scale was later shortened (Borg, 1970; 1973) and although the modified Borg scale is employed around the world, it is not acceptable to many classical psychophysicists. Therefore, in order to justify its use in human movement research, we need to examine it more closely.

Ratings on Borg's (1962) original scale yielded high correlations (0.8 and 0.9) with heart rate when work intensity was varied. When the scale was changed to a fifteen point graded scale, the RPE values followed the heart rate even more closely. In the new scale Borg (1973), the midpoint was lowered and some of the verbal expressions were changed. This compression to compensate for non-linearity slightly reduced the sensitivity of the scale (Carton and Rhodes, 1985), to the point where Mihevic (1983) cast doubt on the ability of the scale in certain situations. Specifically, she stated that the RPE scale may not discriminate between groups of high and low fit subjects working at low to moderate absolute exercise intensities despite differences in physiological strain.

Earlier it was noted that the equal ratios obtained with ratio-scaling techniques follow a geometric series resulting in a power function. In contrast, the equal intervals of the RPE scale followed an arithmetic series and yielded a linear function describing the increment of perceived exertion with increasing work loads (Mihevic, 1983). The Borg scale is based on a correlation between perceived exertion and heart rate, and Borg (1973) proposed that RPE correlated with the actual stress (i.e. work load) and strain (i.e. heart rate). Furthermore, he stated that the addition of a zero to the RPE value should yield a figure which approximates the exercising subject's heart rate. This assumption was however challenged (Pandolf *et al.*, 1972; Pandolf *et al.*, 1978; Mihevic, 1981; Morgan, 1981; Rejeski, 1981; Pandolf, 1982, and Robertson, 1982) and Borg himself (1982) cautioned that this close relationship was not intended to be taken too literally, because the meaning of a certain heart rate value as an indicator of strain depends on various factors such as age, exercise modality, environment and anxiety. For example, on any given day one may run and achieve a heart rate of 150 and feel 'fine' with an RPE of 13,

while on another day the same exertion may cause the runner to feel 'bad' with an RPE of 17 as a result of physical and emotional negative factors.

Using this category rating scale, Borg (1973; 1982) thus found that RPE reflects a linear function of the workload, but this should not be interpreted as conflicting with the results of the ratio-scaling psychophysical studies, in which perceived exertion was found to be a positively accelerated function of the workload. When RPE values are plotted to the corresponding values of the heart rate of the workload, the form of the relationship obtained depends largely on the specific characteristic of the rating scale itself (i.e. the number of categories, the verbal definition etc.) The achievement of a linear relationship between RPE and workload was in fact one of the objectives in the construction and development of the scale. This objective was achieved by a careful choice of verbal categories, by lowering the midpoint of the original 21-point scale and by compressing the lower degrees.

Choice of scaling technique

Ratio-scaling and category-rating scales have been examined. Ratio-scaling procedures provide ratios between exercise intensities or time periods without permitting absolute comparisons of these. Using ratio-scaling procedures, RPE has been shown to grow as a positively accelerating function of exercise intensity. The subjective magnitude of a work bout therefore increases disproportionately as exercise intensity increases. In contrast, category scales require the subject to divide a perceptual continuum into equal intervals in correspondence with available adjectival or numerical descriptions. The observer is therefore forced to attend to intervals or differences rather than ratios (Mihevic, 1983). This facilitates interindividual comparisons among exercise intensities or time periods (Borg, 1973; Morgan, 1981; Borg, 1982).

Category scaling does however have inherent limitations. Firstly a "ceiling" effect (Morgan, 1973) occurs as the subject approaches maximal levels of work, since all subjects are constrained by the upper limit of the scale in that they have to rate 19 or 20. Secondly, category scales fail to reflect the actual sensations perceived across a range of stimulus intensities. This means that category scales suggest that equal increments for a given stimulus are perceived as being the same at light, moderate and heavy work loads, whereas it has been reported that in many different areas of physical work the subjective intensity grows according to a positively accelerated function with the workload (Borg, 1973). Such category scales are rank-order scales, and from their results it can only be stated that one subjective intensity is more "intense" than the other; however, neither the degree of intensity nor the

position of zero intensity can be accurately determined.

In light of the above, Gamberale's (1985) statement that no single subjective reaction, measurement method or experimental strategy is more adequate than others in every condition and for all purposes, seems sound. Morgan (1981) and Borg (1982) have both suggested that the scaling procedure adopted should be determined by the questions being asked. In other words, there is no perfect scale for all kinds of subjective intensities in all kinds of situations, and different scales should be used depending on the purpose of the study.

There is however general agreement (Borg, 1973; Morgan, 1973; 1981; Mihevic, 1981; Borg, 1982; Gamberale, 1985) that the Borg scale should be used in most cases, as it has shown versatility, parsimony and validity. It correlates well with heart rate and its linearity makes it simple to use and makes it easy to perform intra- or extrapolations, bearing in mind the "true" positive acceleration of RPE. In some cases, ratio-scaling techniques are more appropriate, for example when evaluating the growth of subjective sensations with increasing stimulus intensity. When however there is a need to make comparisons between work tasks or between individuals, particularly in clinical and applied settings, the category methods are preferable.

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