Perceived Exertion: 
An Active or Passive Process?

W. Jack Rejeski
Wake Forest University

Subjective estimates of physical work intensity are considered of major importance to those concerned with prescription of exercise. This article reviews major theoretical models which might guide research on the antecedents for ratings of perceived exertion (RPE). It is argued that an active rather than passive view of perception is warranted in future research, and a parallel-processing model is emphasized as providing the needed structure for such reconceptualization. Moreover, existing exercise research is reviewed as support for this latter approach and several suggestions are offered with regard to needed empirical study.

At this point in the history of exercise science, there is substantial agreement that rating of perceived exertion (RPE) has practical utility in the prescription of exercise (Noble, 1982). More specifically, applied physiologists recognize that what people think they are doing is as important in establishing an appropriate exercise intensity as the actual metabolic costs of an activity. Although RPE has often been viewed as the direct result of concrete sensory cues (e.g., muscular strain), Morgan (1973) has noted that roughly one-third of the variance remains unexplained after consideration of physiological input. Furthermore, a number of researchers have emphasized the importance of cognition and motivation/emotion to RPE (see Pandolf, 1983). Hence, it is reasonable to suggest that perception of exertion plays a role in adherence to exercise and is significant to a number of mental health outcomes in which exercise has been implicated (Folkins & Sime, 1981).

Theoretically, two broad but distinct directions are feasible in the scientific investigation of this construct. First, consistent with traditional research, one might elaborate the perceptual basis of RPE. Specifically, what are the antecedents to the self-report of exertion? Or second, as noted by Rejeski and Brawley (1983), exertion can be considered as a construct within cognitive theory. From the perspective of self-perception, the latter orientation offers a framework for examining the consequences of RPE, whereas with person perception my colleagues and I have shown that nonverbal cues of exertion serve as important informational input to first impressions (Lowe, Rejeski, & Green, 1981; Rejeski & Lowe, 1980). The present paper examines theory directed at the antecedents of RPE. The objectives include brief comment on previous theoretical positions and introduction of and elaboration on the utility of an information-processing model.

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Requests for reprints should be sent to W. Jack Rejeski, Box 7234, Wake Forest University, Winston-Salem, NC 27109.
Antecedents of RPE

Theoretical Developments

In a recent review of the RPE literature, Pandolf (1983) traced theoretical developments since Borg's (1970) early statement that an organism's perceptual response to exercise is influenced by extraneous psychological and physiological variables. Clearly, most advancements have been geared toward physiological explanation. In particular, in the early 70s Ekblom and Goldbarg (1971) proposed a two-factor model of RPE giving independent recognition to both central and local input. Subsequently Weiser, Kinsman, and Stamper (1973), employing cluster analysis with cycling data, reemphasized the utility of fractionating perceptual responses; however, they proposed a task-specific trichotomy: local fatigue, cardiopulmonary symptoms, and general fatigue.

More recently, Robertson (1982) suggested that during dynamic exercise the relative contribution of local and central cues to effort sense is mediated by the activity's duration as well as exercise intensity. Accordingly, local cues serve as the sole stimulus for the first 30 s of activity, with central cues potentiating local cues thereafter. Whereas local cues purportedly dominate at varying exercise intensities, central factors become more salient at higher intensities as exercise progresses beyond the 30-s time period. Finally, Cafarelli (1982) has chosen to focus on the obvious importance of local factors, presenting three potential mechanisms through which local sensations become registered in the sensory cortex. Two of the mechanisms rely on a single path, either afferent stimulation from muscular receptors or innervation from the central motor cortex, while the third makes possible the comparison of peripheral muscular stimulation to central motor outflow.

With regard to psychological variables, both Kinsman and Pandolf in conjunction with their associates (Kinsman & Weiser, 1976; Pandolf, Burse, & Goldman, 1975) have theorized that there are discrete symptoms during exercise which fall under the rubrics of task aversion and motivation. Presumably, subjective reports such as RPE result from the reciprocal interaction of these two states with sensory cues from local, cardiopulmonary, and general exertion. Also significant are data supporting the influence of several psychometric variables on RPE (Morgan, 1973) and the proposition that the relative contribution of psychological and physiological input to self-reports of exertion may depend upon the strength of the exercise stimulus (Rejeski, 1981). In more specific terms, there is a point in the physical stress of exercise at which sensory cues, due to their strength, dominate perception. Under such conditions, it seems unreasonable to expect mediation by psychological factors.

Underlying Models

In a cursory review of the RPE literature, it may seem odd that so little attention has been given to discussing the adequacy of theory. Yet one must remember that research has been primarily physiological, a direction in which most investigators assume that RPE has its origin in objective physical sensations. Generalizing from Leventhal and Everhart's (1979) sensory model of pain and in line with psychophysics, perception is a passive process. Hence, the basic goal of scientific inquiry is to examine sensory cues such as changes or absolute values of physiological parameters to determine their role in sensation (see Figure 1 and Mihevic, 1981, for a review of the literature). While physiological input plays a major role in the perception of exertion (Rejeski, 1981), there is strong indication
that perception is an active process (Neisser, 1976). In the words of Pennebaker (1982, p. 20), "Whereas the passive approach attempts to explain much of perception and attention by measurement and understanding of stimulus characteristics, the active approach is more concerned with learning, experience, and sets." Thus, to understand RPE thoroughly and utilize it more effectively in a pragmatic sense, a paradigmatic change seems indicated.

Consistent with Leventhal and Everhart’s (1979) work on pain, those interested in the role of emotion and cognition on the perception of exertion currently espouse one of two positions, either a sequential model or parallel-processing model. In the sequential model, perceived exertion is characterized as an additive process. Specifically, individuals experience particular physical sensations, then react emotionally to these stimuli as a function of past experience and the strength of the stimulus (see Figure 2). Implicitly, this seems to have been the predominant framework guiding model construction (Kinsman & Weiser, 1976; Pandolf et al., 1975) and past research on the psychometric mediation of RPE (Morgan, 1973); at least extant literature does not suggest otherwise.

Although the logic of a sequential model encourages inquiry into personality and social learning as emotionally rooted differences that can alter the interpretation of sensory cues, the proposed mechanism of action is too simplistic. Most notably, it characterizes cortical stimulation by physical sensations as a passive process. In reality, however, empirical data support the position that sensory cues can be manipulated psychologically prior to reaching the cortex (see Leventhal & Everhart, 1979). In other words, similar peripheral physiological changes in two individuals do not necessarily result in identical percepts.

Recently, a parallel-processing model of pain has been proposed (Leventhal & Everhart, 1979) that has interesting ramifications for the study of perceived exertion. This model organizes informational and emotional-distress components in parallel fashion (see Figure 3) as compared to the additive approach illustrated in Figure 2. Contrasted with the sequential model, perception is depicted as an active process and considerable weight is given to preconscious elaboration of sensations. Moreover, the approach distinguishes between perception and focal awareness. Whereas perception refers to all the processed material to which one can attend, focal awareness represents that segment of potential stimuli to which one does attend.

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**Figure 1 — Sensory model (adapted from Leventhal & Everhart, 1979).**

**Figure 2 — Sequential model (adapted from Leventhal & Everhart, 1979).**
Exercise Research Supporting the Parallel-Processing Model

A number of research directions in the exercise literature that are either directly or indirectly related to self-reports of physical work intensity fit nicely into this framework. For example, for some time there has been interest in the role of dissociation as a method of alleviating the discomfort associated with exercise-induced fatigue (Benson, Dryer, & Hartley, 1978). Although dissociation has been shown to be a useful coping mechanism (Morgan, Horstman, Cymerman, & Stokes, 1983), theoretical explanations of why and how it does work often are lacking.

From a parallel-processing perspective, one would hypothesize that dissociative strategies provide a relief from fatigue by occupying limited channel capacity that is critical to bringing a percept into focal awareness. In fact, Pennebaker and Lightner (1980) have demonstrated that during exercise, external cues (e.g., the terrain) do compete with internal cues (e.g., ventilation). Specifically, despite no differences in fatigue ratings, subjects were found to run faster on a cross-country course than on a track. The rationale here is that subjects set their pace in line with fatigue-related symptoms. "Given that subjects were focusing on external cues to a higher degree on the cross-country course, their processing of internal sensations was restricted" (Pennebaker & Lightner, 1980, p. 171).

Further supporting the limited-capacity position is an investigation by Stones (1980). His research was designed to increase the demand on a runner’s visual system by restricting field of vision through the use of specialized goggles. This visual impairment and the subsequent vigilance required for movement resulted in reduced awareness of fatigue-relevant physiological information. Thus, it would appear that what is available in perception can be blocked from consciousness by flooding the lines of communication with distracting stimuli.

In addition to the relationship between perception and focal awareness, a second aspect of the model concerns preconscious elaboration. As one dimension in this phase of the model, Leventhal and Everhart have proposed that individuals may process pain-relevant cues via affective schema, a processing that generates increased reports of distress. Similarly, for a variety of reasons, certain individuals may act on exertional cues with distress schema which can have profound implications for exercise as a health behavior.

Two years ago we became interested in the effect that sex-role orientation might have on college students’ subjective reactions to fatigue. We formulated the hypothesis that, compared to masculine and androgynous women, those typed as feminine would overreact to the distress associated with physical exertion. The initial study involved three groups of subjects (feminine, masculine, and androgynous) running on a treadmill for 30 min at 70% \( \text{VO}_2 \) max (Hochstetler, Rejeski, & Best, 1985). Data indicated that feminine-typed women do report considerably higher RPEs than those typed masculine or androgynous.
(p < .05 for 15-, 20-, 25-, and 30-min marks). Although the masculine versus androgynous comparison was not significant, it was in the predicted direction with the masculine subjects giving lower ratings during the final minutes of exercise. It was particularly interesting that on a pretask measure of affect, feminine women were noticeably pessimistic relative to the other groups. These data combined with previous research on sex roles (Spence & Helmreich, 1978) led to the speculation that, as in research by Leventhal and Everhart (1979), distress schema were responsible for the observed perceptual effect.

A second investigation attempted to manipulate affective schema for feminine women. To accomplish this objective, 40 feminine women were randomly assigned to one of two groups, a distress or nondistress condition. In both conditions, subjects viewed a videotape of a similar other who was performing a cycling task identical to the one they would eventually complete. Previously, a cover letter had stated that the purpose of viewing the tape was to give subjects an idea of what to expect from the experimental task. The distress condition showed a woman who was overtly struggling to complete the task, whereas the nondistress condition depicted the task as slightly demanding but very non-threatening. The data were consistent with the schema hypothesis in that those exposed to the tape showing distress gave substantially higher RPEs at the 10-, 15-, and 20-min marks of a bicycle ergometer ride at 80% VO₂ max than those viewing the tape showing no distress.

At this point the exact role of the schema remains unclear, that is, the schema could actually generate a different percept or the schema may function to make distress cues more available to focal awareness. It is theoretically meaningful to note that the manipulation of schema in this study appear to have been stimulated by attributions of task difficulty, a finding that makes cognitive evaluation particularly relevant to exercise (Rejeski & Sanford, 1984).

More recently the above data have been extended to include men, and we have shown that the observed perceptual differences are manifested in performance (Rejeski, Best, Griffith, & Kenney, 1985). In this investigation three groups of men (feminine, masculine, and androgynous) rode on a bicycle ergometer for 6 minutes at 85% of their estimated VO₂ max, subsequently pushing themselves to exhaustion at 110% of VO₂ max. At the 6-min mark of the submaximal ride, androgynous and masculine men gave lower RPEs than did the feminine men (p < .05). Moreover, those typed as feminine had significantly shorter rides to exhaustion than subjects in the masculine or androgynous categories (p < .05).

Also important is that a Feeling Scale was introduced to assess ongoing affective responses during the submaximal ride. (This is a bipolar scale we constructed which ranges from +5 to −5 with verbal anchors of +5 = very good, +3 = good, +1 = fairly good, 0 = neutral, −1 = fairly bad, −3 = bad, and −5 = very bad.) RPE is a Gestalt measure and thus is insensitive to whether reported exertion is based on informational or emotional cues. Two results with this scale are worth mentioning. First, in the final minute of the submaximal ride, feminine men reported more negative affect than those typed as androgynous or masculine (p < .05) despite the fact that from heart rate data, admittedly a limited physiological parameter, it appears that all three groups were under equivalent physical strain. And second, there was considerable variability in how subjects utilized the RPE and Feeling scales. For example, we observed that at an RPE of 16 some individuals reported feeling good whereas others indicated considerable distress. Based on the schema notion presented previously, both the theoretical and practical implications of this difference merit further empirical consideration.
Recall that the major contribution of a parallel-processing approach is a shift from passive to active perception. Although most of the existing exercise research addressing perceived exertion has not been guided by a formal information-processing model, some additional data do support the notion that perception is an active process. For example, in the clever use of a hypnotic protocol, Morgan and his colleagues (Morgan, Hirta, Weitz, and Balke, 1976) found that the suggestion of heavy and lighter work provoked changes in RPE even though the actual workload remained constant. Moreover, the suggestion of heavy work was associated with an increase in ventilation. What this suggests is that physical sensations can be acted on prior to their becoming a part of perception. Further evidence for this connection can be found in a recent review examining the role of psychogenic factors in exercise metabolism (Morgan, 1985).

**Future Directions**

Several directions of research are suggested by the parallel-processing model. First, we have only begun to tap the processes operative in preconscious elaboration. For detailed insight the reader is referred to Leventhal and Everhart (1979); however, a variety of integrative functions are performed by schemata. For example, in addition to binding emotion to physical sensations, schemata serve as attentional filters that increase individuals' sensitivity to certain stimuli. This would explain why negative attitudes toward exercise promote pretask affective dysfunction. Second, with regard to cognitive coping, consideration should be given to the underlying complexity of various strategies. That is, consistent with the proposition that there are limits to the amount of information an individual can consciously attend to, one would predict that the more complex a dissociative technique, the greater its effectiveness in blocking physical sensations from focal awareness (see McCaul & Malott, 1984, for a detailed articulation of this position). And third, the distinction between awareness and reporting merits investigation. In the attributional literature it is well recognized that self-reports are influenced differentially by public and private contexts (cf. Zuckerman's review, 1979). Thus, subjects may be aware of particular states but withhold revealing such information as a means of facilitating self-presentation.

As a final note, a comment is in order regarding refinements of the parallel-processing model. In particular, from a biochemical perspective, the depletion of energy supplies and the accumulation of exercise metabolites differ sharply from the informational cues typically associated with pain. For example, during high intensity exercise, lactic acid accumulation may preclude one from continuing to endure distress, a condition that ought to be reflected in perceptual responses. As support for this proposition, research has shown that expectations concerning the duration of a task influence RPE most during moderate workloads (Rejeski & Ribisl, 1980). In other words, the positive and negative effects of schemata on perception and tolerance to fatigue may be restricted to specific metabolic demands where there is the absence of strong sensory cues. Also, the model does not provide a framework for conceptualizing how environmental and task variables contribute to the perceptual salience of specific physiological variables during exercise. Advances in physiological theory such as the work by Robertson (1982) may permit the eventual inclusion of such concerns to a comprehensive theory of perceived exertion.
Summary

As researchers, we often forget how critical the structure and underlying assumptions of theory are to the type of questions addressed. There is no doubt that research on RPE within sensory and sequential paradigms has been very productive; however, an information-processing approach emphasizing the active dimension of perception offers a more valid framework for social psychological inquiry. By *active*, the assumption is made that sensory cues for perceived exertion interact with psychological factors prior to perception, and that the conscious recognition of exertional cues is similarly amenable to mediation by cognition/emotion. Because RPE has such a promising role in the study of exercise-related behaviors, renewed emphasis on the nature of theory is warranted.

References


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