A MODEL FOR MENTAL WORKLOAD IN TASKS REQUIRING CONTINUOUS INFORMATION PROCESSING

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INTRODUCTION

The object of this paper is to define and justify a model for mental workload that is appropriate to tasks in which a human operator is required to process sensory information in a continuous fashion. The primary application of this model has been to continuous manual tracking tasks, although certain non-tracking tasks are also candidates for application. The model appears to be most useful as a design and evaluation tool for predicting the relationship between performance and workload; measurements of workload using concepts suggested by the model can be obtained only under highly constrained situations.

In this paper we define workload not in physiological terms but in terms of a performance characteristic of the human operator. Specifically, workload is related to the relative amount of randomness in the human operator's information processing activity, where decreasing randomness is associated with increasing mental effort. Since operator randomness can be associated with a parameter of an existing model for human operator behavior, analytic predictions of performance/workload tradeoffs can be obtained.

The terms "attention" and "workload" are both used in this treatment. It is perhaps natural to consider "attention" as a level of mental effort voluntarily committed to a task, and "workload" as a level of mental effort required by the task. For purposes of model development, the terms are used interchangeably (i.e. the degree of voluntarism is irrelevant to the mathematics of the problem).
The primary intent of this paper is not to present original research results, but to provide a unified treatment of theory, validation, and application of the model for workload and attention proposed and reported by this author and his colleagues (1,2). The section on theoretical development presents the basic assumptions underlying the proposed workload model, shows the equivalence of time-sharing and capacity-sharing notions of attention, presents the basic model of workload, and reviews a human operator model that allows one to predict the relationship between performance and workload. The reader is then directed to the literature for results that validate the basic human operator model as well as the specific model for mental workload, and some pilot-opinion results are cited to support the argument that response randomness can be related to workload and attentional demand. The third major section of the paper discusses predictive and diagnostic applications of the workload model. Finally, some thoughts are offered relating the concepts and techniques discussed in this paper to the goals of the workload symposium to which this paper is submitted.

THEORETICAL DEVELOPMENT

Basic Assumptions

The proposed model for workload is based on the following key assumptions:

1. The mental effort involved in performing a task requiring continuous information processing may, for purposes of mathematical treatment, be attributed to perceptual processing. For example, the workload associated with a single-variable tracking task is equivalent to the attentional demand of the tracking display.

2. The workload imposed by a task requiring processing of multiple sensory inputs is equal to the attentional demands of the various inputs, independent of the degree of linear correlation between these inputs. That is, total workload is computed in the same manner whether the sensory variables relate to a single task or to independent tasks performed concurrently.

3. Each perceptual variable used by the human operator may be considered to be corrupted by a gaussian "white noise" process that is linearly uncorrelated with the sensory input and with other similar noise processes. This "observation noise" process is intended as a mathematical representation of the combined effects of