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SIMILE: A FORTRAN program package for stimulus-integration models

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Stimulus-integration models are used to describe judgment behavior in tasks that require the subject to combine various pieces or factors of information. This theory and its associated procedure of functional measurement have been applied in an increasing number of areas over the last 10 years through the work of Anderson and his colleagues (e.g., Anderson, 1962, 1974, 1978; Birnbaum, 1974; Levin, 1975; Norman, 1976b; Shanteau, 1975). As more researchers apply and extend the application of information-integration theory in different areas, generalized parameter-estimation programs become increasingly useful and in demand. The present paper describes a program package for parameter estimation and model testing that is applicable for broad classes of models and a variety of experimental designs.

For a detailed discussion of integration theory, the reader is referred to Anderson (1974). Three integrating theory functions are shown schematically in Figure 1. The valuation function maps the external stimulus attributes to internal subjective values. No a priori assumptions are made regarding the valuation function except that the subjective values are interval in scale. The integration function maps the n-dimensional subjective value space to a one-dimensional scale representing the internal response. Since both the subjective values and the response are on interval scales, an algebraic function may be used to model the combination rule. Finally, the response function maps the internal response to external response typically on a judgment scale. In general, this function is merely a linear transformation and may be ignored.

From the perspective of parameter estimation and model testing, only the algebraic function and response transformation need be considered. The subjective values are treated as unknown parameters; consequently, the valuation function is superfluous. The problem is to find the solution to a set of simultaneous equations, one equation for each set of stimulus attributes. The experimental design determines the number of equations and the composition of each. The number of stimulus factors and the number of levels on each factor is set by the design and helps to determine the number of subjective value parameters. Typically, the model involves other parameters, such as weights on the stimulus factors. Parameter estimation, then, involves the solution of a set of overdetermined simultaneous equations under the assumption that the response transformation adds normal random error to the observed response. The approach is to define a likelihood function for the observed responses given parameter values and to maximize this function. Solution is achieved by an iterative procedure known as the Newton-Raphson method of scoring (Edwards, 1972) and is described in detail by Norman (Note 1).

The difficulty in developing a general parameter-estimation program has been due to the wide variety of experimental designs and models used in applications of integration theory. Experimental designs have ranged from simple n-way factorials to incomplete fractional factorials and combinations of factorials (e.g., Norman, 1976a). Models have included simple averages, various types of weighted averages, products, and ratios. Furthermore, the specific form and number of parameters of any model vary from one application to another. Consequently, it would not be feasible to write one program to cover all of the possible options. Instead, the approach taken here was to write a program package as a compromise between the overly general and overly specific. This package is called SIMILE.

Description. SIMILE includes two main procedures, a set of common service subroutines, and a set of model subroutines. The two main procedures are FAC-1 and FAC-2. These differ in terms of the allowable options for the underlying distribution function of the data. Both FAC-1 and FAC-2 allow for either homogeneous or heterogeneous cell variance and either independent or correlated observations. In addition, FAC-1 can allow for unit cell variance, and FAC-2 can allow for heterogeneous covariances among cells in the design.

The experimental design may be specified by supplying the factor variates for each stimulus combination or by requesting factorial designs and listing the labels of factors for each design.

Different families of integration models are incor-

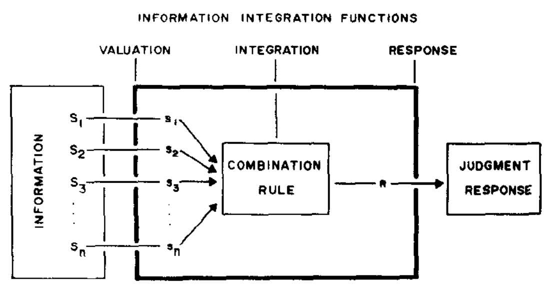

Figure 1. A schematic of the functions assumed in information-integration theory.

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porated by supplying the appropriate model subroutine. The SIMILE package currently includes subroutines for linear, geometric, differential averaging, and ratio models. Each subroutine is written in a general form, so as to allow a number of options concerning the exact model. For example, the linear model may take the form of an adding or an averaging model. Furthermore, a number of restrictions on and among parameters are allowed. In addition to the package subroutines, the user may supply his own subroutine.

Input. The program input is divided into three major sections. (1) The design section requires information about the stimulus or information factors and the experimental design. Factorial designs are specified by listing the factor labels. More exotic designs may be specified by listing factor variates for each stimulus combination. (2) The model and parameter section requires information about the form of the integration rule, the number of parameters to be estimated, assumptions regarding the underlying variance-covariance matrix, and initial estimates of the parameters. (3) The data section requires a FORTRAN format for reading the observed data and, finally, a listing of the data.

Output. The program output is also divided into three sections. (1) Summary statistics on the observed data are generated. (2) A listing of intermediate results may be output following each iteration for diagnostic results. (3) The final parameter estimates are listed along with the variance-covariance matrix of the estimates, the theoretical means generated by the model, and a maximum-likelihood ratio test of the model. In addition, some diagnostic messages exist to help the user correct problems.

Limitations. The current version of SIMILE is limited to 10 stimulus factors and a maximum of 25 parameters. FAC-1 allows up to 200 stimulus combinations in the design, and FAC-2 is limited to 100 stimulus combinations. These limits may be extended by redimensioning arrays.

Computer and Language. SIMILE may be compiled under FORTRAN IV on a UNIVAC 1100 series computer. The program may be easily recoded so that it can be implemented using other FORTRAN compilers. Double-precision variables and arithmetic are used in all noninteger computations.

Availability. The source listing of SIMILE programs with sample input and output, a program write-up giving detailed instruction on the use of the program, procedure, and a technical write-up of the parameter estimation are available free of charge from Kent L. Norman, Department of Psychology, University of Maryland, College Park, Maryland 20742. In addition, source decks and audio cassettes (110- or 300-baud ASC11) of SIMILE are available at a nominal charge to cover cost of the medium.

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