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INTEGRATION THEORY AND ATTITUDE CHANGE[1]

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A theory of information integration is applied to attitudes and social judgments, based on a principle of information integration. For quantitative analysis, a simple but general algebraic model of judgment is used, in which each informational stimulus is characterized by two parameters, scale value and weight. Functional measurement procedures are employed to derive equal-interval scales of parameter values. Exact tests based on analysis of variance are given for four applications of the model, and these applications are reconsidered under the further restriction imposed by the averaging hypothesis. Qualitative comparisons are made to several other theories of attitude change. Tendencies toward balance and congruity are shown to be consequences of the principle of information integration. Critical tests between integration theory, and balance and congruity theories are also suggested. Similar comparisons are made to summation theory, logical-consistency theory, assimilation-contrast theory, and similarity-attraction theory. Molar and molecular analyses of communication structure are considered briefly and the analysis of inconsistency resolution within integration theory is also discussed. Finally, it is noted that integration theory has had reasonable success in the areas of learning, perception, judgment, decision making, and personality impressions, as well as attitude change. It may thus provide a beginning to a unified general theory.

Attitude change stands out from most areas of experimental psychology in the nature of its stimuli. In even the simplest investigations of attitudes and opinions, the stimuli typically carry information at a cognitive level not often reached in other areas of research. Informational stimuli continually impinge on the person, in life or in the laboratory, and he must integrate them with one another as well as with his prior opinions and attitudes. Social judgments are typically based on a cumulation of various pieces of information, sometimes of the most diverse nature. Factual and hearsay evidence, rumors, prestige associations, gesture and appearance, may all bear on the final attitude. Information integration is thus fundamental in attitude change.

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In previous research, the writer has been working on a general theory of information integration. Experimental applications have ranged from personality impression formation to decision making and psychophysical judgment. The present paper gives a more detailed exposition of integration theory in attitude change, developing further the theme of some of the first reports in this research program (Anderson, 1959a; Anderson & Hovland, 1957) and of more recent work (Anderson, 1968a).

INTEGRATION THEORY

Integration Model

A basic distinction in the present formulation is that between weight and value. Each piece of information is represented by two parameters: a scale value, s, and a weight, w. The value is the location of the informational stimulus along the dimension of judgment. The weight represents the psychological importance of the information. It is important to note that both s and w will depend on the dimension of judgment as well as the individual. For simplicity, only a single dimension of attitude or judgment will be explicitly considered. The same piece of information may have quite different value and importance on different dimensions, or for different individuals on the same dimension.

The theoretical model used in most of this work can be written as a weighted sum:

$$R = C + \sum_{i=0} w_i s_i. \qquad [1]$$

Usually, R is taken to be the overt response, measured on a numerical scale. In some cases, however, R might be considered as the attitude underlying an overt yes–no decision. The summation in Equation 1 is over all relevant informational stimuli. The contribution of Stimulus i is just its weight w_i times its value s_i. The constant, C, allows for an arbitrary zero in the response scale and will not be explicitly considered here. The first term in the sum, $w_0 s_0$, represents the initial opinion, prior to receiving the informational stimuli.

Two basic algebraic operations, adding and multiplying, are involved in the integration model. In simplest form, the total effect of any one informational stimulus is the product of its weight and its scale value. The total effect of two or more informational stimuli is the weighted sum of their scale values. These two algebraic operations correspond to two classes of experimental manipulations in attitude experiments as noted below.

Despite its simple nature, the algebraic judgment model has considerable flexibility. It includes adding, averaging, subtracting, dividing, and multiplying models, as well as proportional-change and linear operator models. Special cases have been studied by numerous investigators in varied areas as cited here and elsewhere (Anderson, 1970a; S. Rosenberg, 1968).

Empirical Support

The writer's program of research in information integration has been based on a systematic exploitation of the algebraic judgment model. A substantial portion of the work has dealt with personality impressions (see Anderson, 1968a), including the study of stimulus interaction and configural use of cues (Anderson, 1965b; Anderson & Jacobson, 1965; Lampel & Anderson, 1968; Sidowski & Anderson, 1967). Other applications include decision making (Anderson & Shanteau, 1970; Shanteau, 1970a), psychophysical judgment (Parducci, Thaler, & Anderson, 1968; Weiss & Anderson, 1969), illusions (Anderson, 1970b; Massaro & Anderson, 1971), learning (Anderson, 1969b; Friedman, Carterette, & Anderson, 1968; Himmelfarb, 1970), and attitude change (Sawyers & Anderson, 1971).

The integration model has done well, both qualitatively and quantitatively. It rests upon a substantial data base. Although a major part of the supporting experimentation has been done with personality impressions, the same principles may be expected to apply to the more traditional communication-persuasion paradigm. Indeed, personality impression formation involves attitude change toward a particular individual and can be viewed as a miniature attitude change situation. Each trait adjective corresponds to a communication whose weight can be controlled by attributing it to various sources, for instance, or by manipulating its reliability. The development of personality impressions and attitudes both involve the integration of information into evaluative judgments that have social relevance. From the present standpoint, an a priori distinction between them would be artificial.

Valuation and Integration

The two fundamental operations in integration theory are valuation and integration. Valuation, in model terms, involves the determinants and the measurement of the w and s parameters. Integration comprises the ways in which the several stimuli are combined. The judgment task may affect the integration rule and certainly will affect the valuation process. In general, however, valuation and integration may conveniently and effectively be kept separate as long as the stimuli do not interact.

When the stimuli do interact, valuation and integration will become interlinked. As a working rule, it will be assumed here that stimulus interaction primarily affects the valuation process, and that the changed parameter values are then employed in the integration.

Most of the experimental work to date has used the assumption that the w and s values for an informational stimulus remain constant, regardless of what other stimuli it may be combined with. This is convenient in tests of the model, particularly in the early stages of development. Fortunately, the assumption that the stimuli do not interact seems to be justified in an important group of situations.

More interesting though more difficult problems arise in the many situations in which context-induced changes may occur. Primacy effects (Anderson, 1965b; Asch, 1946), positive context effects (Anderson, 1966a; Kaplan, 1971), discounting effects (Anderson & Jacobson, 1965; Lampel & Anderson, 1968; Schümer & Cohen, 1968), and differential weighting (Oden & Anderson, 1971) have all been studied in personality impressions with some theoretical success. Such problems of configural cue usage are even more important in the general study of attitude change as the latter discussion of the source-communication relation will show.

The problem of stimulus configurality also bears directly on the problem of cognitive structure. A personality impression, for example, or even a trait adjective, obviously has a more complex cognitive structure than can be represented on a single dimension. A multidimensional representation would do better, of course, and the present development may be considered as applying to each of several dimensions in turn.

However, the undoubted success of the dimensional view in psychology can lead to preoccupation with a restricted set of problems, and to a possibly artificial view of cognitive structure. Information integration, for example, may itself occur at a more basic level than the judgment, and the latter may be merely the valuation of the structure along the specified task dimension (Anderson, 1967). The standard dimensional view will be used in this paper, but its probable limitations need particular attention in the study of stimulus interaction. For example, the data suggest that affective and semantic inconsistency produce about equal discounting (Anderson & Jacobson, 1965). In inconsistent combinations, the response must be based on the stimulus configuration, and it is problematic how far standard dimensional representations of the stimulus will go.

Application to Attitude Change

In attitude change, the source-communication-issue schema developed most extensively by Hovland and his associates (e.g., Hovland, 1957; Hovland, Janis, & Kelley, 1953) provides a useful way to organize many problems. A communication from some source provides information that is relevant to the person's attitude or opinion on some issue. The effective stimulus is then the source-communication combination. The present use of two parameters, weight and scale value, to represent the source-communication parallels the approach of Anderson and Hovland (1957).

The scale value of the source-communication corresponds to its position on the attitude dimension. For many purposes, this can be taken as the position advocated by the source-communication. This value will be primarily determined by the semantic properties of the communication, as they are interpreted within the person's value system. Conceptually, it is sometimes useful to consider the scale value as the attitude that would be left unchanged by the communication.

The weight parameter is more important theoretically than the scale value because of the many determinants of the weight. A primary determinant of w_i will be characteristics of the source. Thus, source status, reliability, and expertise will all affect w_i. Moreover, w_0, the weight parameter of the initial opinion, will reflect personality characteristics, such as persuasibility, as well as ego involvement and strength of prior opinion. In addition, the evidence indicates that primacy and recency effects are to be interpreted in terms of the weight parameter as discussed later.

Because of its close relationship with functional measurement, integration theory emphasizes a more quantitative approach to communication-persuasion processes than has been usual in attitude theory. Traditional approaches have been more concerned with qualitative analysis of valuation than with integration per se. Since functional measurement opens up possibilities for direct measurement of the stimuli, the present approach is less exclusively concerned with qualitative analysis. Moreover, because the theory rests on a principle of information integration, the experimental program has emphasized the study of information variables in the stimulus. As will become apparent, some of the traditional problems of attitude theory are particularly amenable to analysis within a conceptual framework based on information integration.

Functional Measurement

The power of the algebraic judgment model has depended on the concomitant development of a theory of functional measurement. This scaling theory makes it possible to get the equal-interval scales that are needed in the quantitative tests of the model. The basic ideas of functional measurement were given in two early papers (Anderson, 1962a, 1962b), and a more systematic exposition in psychophysical judgment is given in Anderson (1970a). A brief sketch will be given here; the later theoretical applications will exhibit functional measurement in action.

A central idea of functional measurement is that measurement scales are derivative from substantive theory. Measurement thus involves three simultaneous problems (Anderson, 1970a, Figure 1): (*a*) Problem 1—to measure the subjective stimulus values on equal-interval scales; (*b*) Problem 2—to measure the subjective response value on an equal-interval scale; and (*c*) Problem 3—to find the psychological law that relates the subjective values of stimuli and response. All three problems are to be solved together. That this can sometimes be done quite simply is shown in previous experimental work using functional measurement procedures (e.g., Anderson, 1962a). These procedures are illustrated in the next section.

Nearly all the experimental work in this research program has used numerical response measures such as ratings. But rating scales may be only ordinal, while the exact tests of the model require an equal-interval scale. Functional measurement allows transformation of an ordinal scale into an equal-interval scale on the response side. Functional scales on the stimulus side can then be obtained. The algebraic judgment model is used as the scaling frame so that the validity of the scales depends on the validity of the model. Substantive theory and measurement theory are thus cofunctional in development.

Functional measurement may be contrasted with Thurstonian scaling in several respects, two of which should be noted here. First, the Thurstonian approach is largely concerned with stimulus scaling, which is traditionally seen as a preliminary to the substantive inquiry. Such an approach has its attractions, but it bases the substantive investigation on a separate scaling theory of uncertain validity and relevance. Many workers, as a consequence, have attempted to develop "measurement free" methods that use only rank-order information. The present approach, in contrast, treats scaling and theory as inherently interlinked at every level of consideration.

A second difference between functional measurement and Thurstonian scaling is in the treatment of individual differences, a problem of some importance in attitudes and opinions. As is well known, Thurstonian paired-comparison scales of attitudinal stimuli almost necessarily rely on pooled group data. Most people will have clear preferences, and the resultant 0–1 probabilities disallow scaling at the individual level. Group scales (Bock & Jones, 1968, pp. 1–2) have normative and sociological value, as in Coomb's (1967) replication of Thurstone's (1927) scale of seriousness of offenses. However, their role in the study of psychological processes is severely limited. Functional measurement has the important advantage that it can operate directly at the level of the individual.

Conceptually, the response scaling feature (Anderson, 1962b, 1970a; Bogartz & Wackwitz, 1970, 1971) is essential to functional measurement. The logic of this approach rests on "using the postulated behavior laws to induce a scaling on the dependent variable" (Anderson, 1962b). Indeed, it would not be possible to consider this approach as a general theory of measurement without systematic methods for transforming ordinal response measures to an interval scale. Experimental illustrations are given in Anderson and Jacobson (1968) and Weiss and Anderson (in press).

For the kinds of situations considered in this article, however, there is increasing evidence that ordinary rating procedures can provide interval scales simply and directly, at least with reasonable experimental precautions (e.g., Anderson, 1967; Himmelfarb & Senn, 1969; Shanteau & Anderson, 1969). In this article, therefore, it will be assumed that the observed response is on an interval scale. This assumption is directly testable since an inadequate scale would tend to disconfirm the model predictions. Conversely, if the model does fit the data, response scale and model are jointly validated.

From the experimental standpoint, an important methodological feature of functional measurement is the use of stimulus combinatorics. Each informational stimulus is systematically placed in several different combinations. This experimental strategy embodies a direct approach to the substantive problem of stimulus integration. Happily, it also allows the effect of the given stimulus to be factored out and scaled. Extensive use is made of factorial designs, therefore, with analysis of variance a principal tool.

Conjoint measurement (Krantz & Tversky, 1970; Luce & Tukey, 1964) has certain similarities to functional measurement, but as a matter of principle restricts itself to rank-order data. Its principal virtue seems to be that it can provide rank-order tests of goodness of fit for certain models. That virtue bypasses the response scaling problem, which could certainly be advantageous, though practical difficulties seem to have limited the use of these techniques (Tukey, 1969; Zinnes, 1969). Functional measurement, in contrast, enables one to use whatever metric information is in the overt response. In that sense, the difference between functional and conjoint measurement parallels that between parametric and nonparametric tests (Anderson, 1961a). At a more fundamental level, the functional measurement approach makes measurement theory an integral part of substantive psychological theory. As one consequence, it has the flexibility needed to cope with nonadditivities caused by averaging processes and certain kinds of stimulus interactions.

MATHEMATICAL APPLICATIONS

This section details several applications of the integration model, and much of it can be skipped initially. After the next two subsections, therefore, and the initial remarks on the averaging hypothesis, it may be desirable to go to the main section of the paper, Relations to Other Theories.

Basic Integration Rules

The applications below all rest on two kinds of experimental manipulations: of the weight parameter and of the scale value. These correspond to three basic integration rules. The first is a multiplying rule which specifies the total effect of a communication to be the product of its weight and its value. The rationale for this multiplying rule can be illustrated by considering any method of manipulating weight. Source credibility, for example, does not of itself produce opinion change, but only affects degree of acceptance of the communication. A decrease in source credibility would thus act by attenuating the effect of the communication.

The second basic integration rule specifies that two communications will follow some kind of adding rule, as in Application 1 below. An adding-type rule is intuitively attractive and has been employed in some form in almost all attempts at quantitative analysis.

However, there is considerable evidence for an averaging rule instead of an adding rule. Mathematically, the two rules have considerable similarity, though the averaging rule tends to be more difficult to work with. In many cases, the two rules make the same prediction, but they disagree markedly in some important situations as discussed under Averaging Theory.

Psychologically, adding and averaging are quite different. In a strict adding model, the informational stimuli can be completely independent in their action. In contrast, averaging always implies some degree of cognitive interaction because the weight of any one informational stimulus necessarily depends on all the others. Accordingly, averaging is considered as a third basic rule and considered separately in the next section.

A comment on terminology may help avoid some ambiguity in the use of the terms "adding" and "averaging." Because they make the same predictions under certain conditions, there may be neither need nor basis to make a distinction. In many of the published papers that have employed one or the other model, no distinction has been necessary. In line with mathematical usage, therefore, the term adding will be used generically to include both strict adding and averaging models. When the discussion is to be restricted to one or the other, this will be indicated. The results of the following four applications do not all hold for averaging models as discussed in the next main section on averaging theory.

Application 1: Variation in s

This application is appropriate when two (or more) communications that have different scale values on a given issue are combined. In the experiment cited below, for example, the communications were paragraphs that described good and bad actions of United States Presidents.

It is assumed that the communications are presented according to a Row × Column factorial design as illustrated in Table 1. The row and column factors each correspond to one source, and the levels within each factor correspond to communications attributed to the row source and column source, respectively. The source may be only implicit, when the communications are presented as historical fact, for example.

Under an adding model, the theoretical entry in each cell of the design is

$$R_{ij} = w_0 s_0 + w_R s_{Ri} + w_C s_{Cj}. \qquad [2]$$

Here w_R and w_C are the communication weights associated with the row and column sources; s_{Ri} is the scale value of the communication coming from Source R in row i; s_{Cj} is the scale value of the communication from Source C in column j. Each opinion is thus considered as the resultant of three informational stimuli: the two communications and the initial opinion. The initial opinion will be assumed equal to zero, a simplification that does not affect the conclusions.

Equation 2 imposes two assumptions: The first is that the communications do not interact or change scale value when combined. The second is that the row weight, w_R, is constant over rows and analogously for the column weight. Since w_R represents the joint effect of the row source and the row communication, this virtually requires that each row communication have the same natural weight and that source and communication do not interact.

These restrictive assumptions should be kept in mind when designing an experiment. They are, however, more restrictive than necessary for an adding model. Application 4, below, allows the weights to vary across rows and/or columns and still yields exact predictions.

Test of fit. For this design, the model makes a very simple prediction: each two rows differ by a constant. For example, the difference between rows 1 and 2 in each column of Table 1 is $w_R(s_{R1} - s_{R2})$.

If the model is correct, then the raw data should show a very simple pattern. Graphically, the three rows of data should plot as three parallel curves except for sampling error. An example based on Table 1 is given in Figure 1 in the next section. Statistically, this means that the Row × Column interaction is zero in principle and nonsignificant in practice. Thus, regular analysis of variance provides a simple and powerful test of goodness of fit.

It may be reemphasized that this parallelism test can be made directly on the raw data. The person receives the two informational stimuli and then makes his response on a numerical scale. The test is made directly on these responses. Separate esti-

TABLE 1

INTEGRATION MODEL ILLUSTRATED FOR TWO-COMMUNICATION FACTORIAL DESIGN WITH VARIOUS COMMUNICATIONS ATTRIBUTED TO EACH OF TWO SOURCES

A. Formal model expressions

Source R (w_R)	Source C (w_C)				
	Communication C1	Communication C2	Communication C3	Communication C4	M
Communication R1	$w_R s_{R1} + w_C s_{C1}$	$w_R s_{R1} + w_C s_{C2}$	$w_R s_{R1} + w_C s_{C3}$	$w_R s_{R1} + w_C s_{C4}$	$w_R s_{R1} + w_C \bar{s}_C$
Communication R2	$w_R s_{R2} + w_C s_{C1}$	$w_R s_{R2} + w_C s_{C2}$	$w_R s_{R2} + w_C s_{C3}$	$w_R s_{R2} + w_C s_{C4}$	$w_R s_{R2} + w_C \bar{s}_C$
Communication R3	$w_R s_{R3} + w_C s_{C1}$	$w_R s_{R3} + w_C s_{C2}$	$w_R s_{R3} + w_C s_{C3}$	$w_R s_{R3} + w_C s_{C4}$	$w_R s_{R3} + w_C \bar{s}_C$
M	$w_R \bar{s}_R + w_C s_{C1}$	$w_R \bar{s}_R + w_C s_{C2}$	$w_R \bar{s}_R + w_C s_{C3}$	$w_R \bar{s}_R + w_C s_{C4}$	$w_R \bar{s}_R + w_C \bar{s}_C$

B. Numerical example

Source R ($w_R = 1$)	Source C ($w_C = 2$)				
	$s_{C1} = 1$	$s_{C2} = 2$	$s_{C3} = 3$	$s_{C4} = 6$	M
$s_{R1} = 1$	3	5	7	13	7
$s_{R2} = 2$	4	6	8	14	8
$s_{R3} = 6$	8	10	12	18	12
M	5	7	9	15	

mates of the scale values of the communications are not required. This is invaluable in attitude research because prior scaling of the communications is often undesirable or infeasible.

Application 1 has special interest because it holds when the communications are presented in strictly serial order as is typical of attitude change situations. The row factor then corresponds to the first communication, the column factor to the second communication, etc. Applications of such serial-factor designs have been made in a number of other areas (e.g., Anderson, 1964d; Shanteau, 1970a; Weiss & Anderson, 1969). Under certain conditions, it is possible to construct the serial-position curve knowing only the response at the end of the sequence.

Functional scales. A striking property of the integration model is that it provides a method for scaling the communications. In Table 1, the column means are linear functions of the s_{Cj},

$$\bar{R}_j = w_R \bar{s}_R + w_C s_{Cj}, \qquad [3]$$

where the mean row value, $\bar{s}_R$, is a constant. The observed column means, therefore, are estimates of the communication values on an equal-interval scale.

This is illustrated in the numerical example in the lower half of Table 1. The column means are twice the column scale values plus 3; the row means are the row scale values plus 6. These interval scales have arbitrary zero and unit and are unique only up to a linear transformation. This needs to be kept in mind for scaling purposes; more than two row stimuli would ordinarily be needed to estimate any scale values for the row stimuli. Of course, no more than two rows are needed for the test of fit, and two rows suffice for scaling under certain conditions when the same stimuli are used in each factor of the design (e.g., Weiss & Anderson, 1969).

These results are not restricted to two-way designs but hold for any number of factors. The first experimental application of functional measurement (Anderson, 1962a) used a three-way design for personality impressions.

Experimental example. Figure 1 shows an experimental test of integration theory. Subjects judged general statesmanship of various United States Presidents, each de-

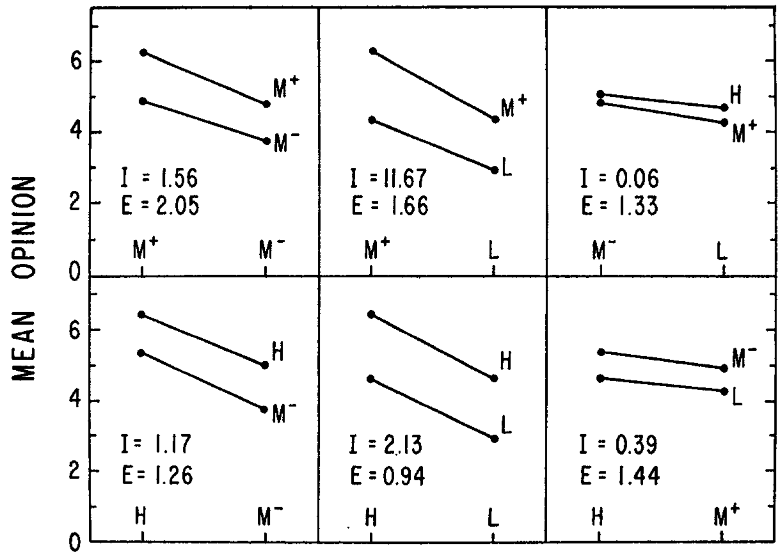

FIG. 1. Mean attitude toward United States Presidents produced by pairs of informational paragraphs. (Equal weighting model predicts parallelism for the 2 × 2 design in each panel. Mean squares for interaction and error denoted by I and E. H, M^+, M^-, and L denote paragraphs of highly favorable, moderrately favorable, moderately unfavorable, and very unfavorable information.) (Reprinted from an article by Barbara K. Sawyers and Norman H. Anderson published in the May 1971 *Journal of Personality and Social Psychology*. Copyrighted by the American Psychological Association, Inc., 1971.)

scribed by two paragraphs based on historical sources (Sawyers & Anderson, 1971). Very positive, mildly positive, mildly negative, and very negative paragraphs are denoted by H, M^+, M^-, and L. Each panel shows a 2 × 2 design which should obey the parallelism prediction. Parallelism seems to hold fairly well except that the discrepancy was significant in the top center panel.

Adding and averaging models make the same parallelism prediction in this experiment and are not distinguishable from these data. However, subsequent work appears to rule out the adding model for President judgments.

The parallelism test is made directly on the raw response and does not require actual estimation of the scale values. Normative ratings were used to class the paragraphs as H, M^+, M^-, or L, but the only function of these categories was to separate the data curves in order to allow potential nonparallelism to appear. It should be noted that the 2 × 2 design is frequently not convenient or usable for functional scaling. However, the primary purpose of this experiment was to test the model rather than scale the stimuli.

Application 2: Variation in w

This application is similar to the first, but with manipulation of the weight parameter instead of the scale value. This application would be appropriate for studying the combined effects of two different sources. Since it can provide an interval scale of the weight parameter, it may be especially useful in the analysis of the many determinants of source effects.

A factorial design is employed, as in Application 1, but with the roles of w and s interchanged. Each factor corresponds to one communication; the levels within each factor correspond to different sources to which the communication is attributed. For a two-way design, the model becomes

$$R_{ij} = w_0 s_0 + w_{Ri} s_R + w_{Cj} s_C, \qquad [4]$$

parallel to Equation 2.

The assumptions of Equation 4 are analogous to those of Equation 2, though perhaps more easily satisfied in practice. The row communication is assumed to have the same scale value regardless of which source it is combined with, and similarly for the column communication. The weight of each communication depends on the source and will in general be different in each row and column. Finally, as in all these applications, it is assumed that the combining of two stimuli within any cell of the design does not change the parameter values.

For a strict adding model, the analysis is identical to that of Application 1. If the data satisfy the model, therefore, they provide equal-interval scales of the weight parameters. This application may thus be useful in the analysis of source effects, though it should be recognized that it assumes a strict adding model.

Application 3: Variation in both w *and* s

Application 1 was concerned with how two communications are combined, and Application 2 with how two sources combine. Application 3 is concerned with how one source and one communication combine. It may be particularly useful when only a single source-communication can be given.

Mathematically, Application 3 is interesting since it rests on a multiplying model instead of an adding model. As a consequence, the model analysis requires some new developments. A two-way factorial design is used again, but with the row factor representing different sources and the column factor representing different communications. The model then becomes

$$R_{ij} = w_0 s_0 + w_{Ri} s_{Cj}, \qquad [5]$$

where w_{Ri} is the weight of the source in row i, and s_{Cj} is the value of the communication in column j. In contrast to Applications 1 and 2, there is only one communication in each cell of this design. The assumptions required by Equation 5 are that the weight parameters depend only on the row and the scale values depend only on the column.

Equation 5 is a multiplying model, since the initial opinion term is just an additive constant. Functional measurement for multiplying models has been discussed for psychophysical judgment (Anderson, 1970a), and it has been used to scale subjective probability and utility in decision-making experiments (Anderson & Shanteau, 1970; Shanteau, 1970b). The same approach may be used here.

TABLE 2

HYPOTHETICAL DATA FOR SOURCE × COMMUNICATION DESIGN TO ILLUSTRATE FUNCTIONAL MEASUREMENT FOR A MULTIPLYING MODEL

Source	Communication					
	1	2	3	4	5	M
1	9	14	29	24	44	24
2	8	12	24	20	36	20
3	6	8	14	12	20	12
4	5	6	9	8	12	8
M	7	10	19	16	28	
Est(s_j)	0	1	4	3	7	

The hypothetical data of Table 2 will illustrate the procedure. Each entry is to be considered as the attitude resulting from one combination of source and communication. The first step is to test whether these data follow the multiplying model of Equation 5.

Test of fit. Testing the model would be straightforward if the communication scale values were known. Plotting the entries in any one row as a function of the s_{Cj} would, if Equation 5 was correct, yield a straight line with slope w_{Ri}. Although the s_{Cj} are not known, this idea provides the basis for solving the problem.

A simple graphic solution may be obtained as follows. First, two communications are assigned arbitrary values: in Table 2, the first two communications have been assigned the values 0 and 1 in the last row of the table. The observed means for these communications, 7 and 10 in the table, are plotted as a function of these assigned scale values. These two points define a straight line, and each remaining communication mean is then marked on this line at its proper elevation. The downward projection of this point on the value axis is a provisional estimate of the scale value of that communication. Thus, if 19 is marked on the line joining 7 and 10, its projection on the value axis, namely 4, is a provisional estimate of the scale value of Communication 3. In the same way, the scale values of Communications 4 and 5 are estimated as 3 and 7 in the last row of the table.

The final and critical step is to plot the data of each separate row as a function of these provisional scale values. If the model is correct, these row curves will form a family of diverging straight lines. Deviations from this pattern would infirm the model.

To supplement this graphical test, an exact statistical test is also available by appropriate use of analysis of variance. Since the model predicts nonparallel curves, the Row × Column interaction is nonzero. However, if the model is correct, all the interaction is concentrated in the Linear × Linear component, and the residual interaction should be nonsignificant (Anderson, 1970a, p. 157).

Two extensions of this application deserve mention. The first adds on a second two-way design so that each cell contains two such source-communication combinations. The analysis would then be similar to the duplex bets studied in Anderson and Shanteau (1970). Another extension adds on a third factor representing a second source variable so that each communication is attributed to two sources. This would be useful in the theoretical analysis of source combinations.

Functional scales. Verification of the model simultaneously validates the provisional scale values used in testing it. Indeed, Equation 5 implies directly that the column means of the Source × Communication design are a linear function of the communication values, s_{Cj}. Similarly, the row means are a linear function of the source-communication weight, w_{Ri}. The marginal means of the factorial design thus provide equal-interval scales of the stimulus parameters. The multiplying model is just like the adding models in this respect.

Application 4: Variation in both w *and* s

The last application is a generalization of Application 1 in which a different source-communication is allowed in each row and in each column. It may thus be applicable to situations in which the communication interacts with the source, as in studies of source expertise.

A two-way factorial design is used again. The strict adding model then implies that

$$R_{ij} = w_0 s_0 + w_{Ri} s_{Ri} + w_{Cj} s_{Cj}, \qquad [6]$$

in which different weights and values are allowed in each row and in each column. The only restrictive assumption is that the row and column stimuli do not interact when combined in any cell. However, source and communication in any given row or column may interact in any manner.

Even in this general case, the adding model still makes the parallelism prediction. Analysis of variance can thus be applied just as in Application 1. There is a loss in precision since the functional scales do not separate the weights and the scale values. Nevertheless, the row means still measure something useful, namely, $w_{Ri} s_{Ri}$, which is just the total effect of the given communication.

Applications 1 and 4 bear a close relation. In practice, the row weight in Equation 2 might depend on the scale value of the communication. It could not then be considered as a constant, w_R, but would need to be taken as a variable, w_{Ri}. The adding model predicts parallelism in either case. In an averaging model, however, the analysis becomes more difficult as will now be seen.

AVERAGING THEORY

There is increasing evidence for the importance and ubiquity of averaging processes in information integration. This finding has fundamental importance in integration theory. It affects every aspect of an experiment, from general design and procedure to theoretical interpretation. The critical evidence will be briefly noted, and then the four applications discussed above will be considered from the averaging standpoint.

Averaging versus Adding

Two main experimental paradigms have been used for critical comparisons between averaging and adding. First, adding mildly polarized to highly polarized stimulus information decreases response polarity (Anderson, 1965a; Anderson & Alexander, 1971; Hendrick, 1968; Lampel & Anderson, 1968; Manis, Gleason, & Dawes, 1966; Levin & Schmidt, 1970; Oden & Anderson, 1971). This result eliminates a direct adding formulation, though it might be saved by postulating a contrast effect. Thus, an adding model would predict a decrement if mildly favorable information received a negative evaluation in the context of highly favorable information. It seems doubtful that such contrast effects play an effective role with verbal stimuli (e.g., Anderson, 1971a, 1971b; Anderson & Lampel, 1965; Kaplan, 1971; Tesser, 1968; Wyer & Dermer, 1968), but the possibility cannot yet be ruled out.

The second result is that adding information of the same value typically makes the response more extreme; this is the familiar set-size effect. Qualitatively, the set-size effect accords with an adding process, though no adding formulation has yet given a quantitative account. More seriously, the set-size effect eliminates a simple averaging model in which a constant stimulus mean would produce a constant response.

The present averaging formulation accounts for the set-size effect by the use of an initial opinion. The set-size function is then a growth curve of somewhat different form for serial presentation (Anderson, 1959a) than for simultaneous presentation (Anderson, 1965a). In this form, the averaging model can give a good quantitative account of the set-size effect (Anderson, 1967).

This last point bears emphasis in two respects since it has sometimes been misinterpreted. First, the averaging formulation can account for both incremental and decremental effects of added information, so there is no need to postulate two processes. Second, the averaging formulation has given exact, quantitative accounts of both the incremental and decremental effects.

An interesting appearance of the set-size effect can be seen in an argument of M. J. Rosenberg (1968), who makes the plausible argument that a given piece of information that could produce considerable opinion change if the issue was new and unfamiliar would have little effect if the issue was old and familiar. Rosenberg interpreted this argument against averaging as well as adding. However, it accords with the averaging set-size function on which the old opinion, based on a considerable accumulation of information, would be near asymptote. More precisely, the old opinion, being based on much more evidence, would have a much greater weight parameter than the new opinion. In the averaging formulation, the weight of the given piece of information must then be much less relative to the old opinion, since the weights must sum to one.

Averaging Assumptions

Mathematically, the difference between adding and averaging models is simple. Adding models impose no constraints on the weight parameters, whereas averaging models require the weights to sum to one.

Averaging always implies stimulus interaction because of this constraint on the weight parameters. In an adding model, the effect of any one stimulus may be independent of the other stimuli. But in an averaging model, the effect of any one stimulus is inherently dependent on the whole set of information. In a certain sense, therefore, an averaging model has gestalt qualities, since the role of each part depends on the whole.

For present purposes, therefore, the assumption of no interaction will be used to mean that each stimulus has a natural or absolute weight which, together with its scale value, is constant across stimulus combinations. The effective weight of each stimulus is then its absolute weight divided by the absolute weights of all the stimuli in the given combination. In this way, each application considered above is directly convertible to an averaging model by dividing by the sum of the weights, and this procedure will be followed here. These effective or normalized weights sum to one for each stimulus combination. Mathematically, it is often convenient to use unnormalized weights at intermediate stages in the calculations or derivations.

Application 1

For this application, the weight w_R was assumed constant across rows, and the weight w_C was assumed constant across columns. Equation 2 then implies that the sum of the weights, $w_0 + w_R + w_C$, is constant, the same in each cell of the design. Dividing each predicted attitude by this constant is equivalent to changing the unit or range of the response scale. Since the scale unit is arbitrary, adding and averaging are not distinguishable under the given assumptions. Both predict parallelism, and both yield interval scales of the stimuli.

This equivalence of the two models disappears as soon as the weights vary across rows or columns. Not much is lost under the adding model; it still predicts parallelism as discussed under Application 4 above. But since the sum of the weights will now vary from cell to cell of the design, the averaging model predicts systematic deviations from parallelism.

Because of this complication in the averaging analysis, experimental precautions to help ensure equal weighting may be worthwhile. Of course, this may not be possible when the stimuli vary naturally in weight. In the personality-impression task, for instance, the response to a combination of moderate and extreme negative adjectives is displaced toward the extreme (Anderson, 1965a, 1968b; Anderson & Alexander,1971). This directional result is consistent with the hypothesis that the extreme adjectives have greater natural weight and is one piece of evidence that favors the averaging hypothesis.

Application 2

The averaging model is quite different from the strict adding model in this design. Written as an averaging model, Equation 4 becomes

$$R_{ij} = (w_0 s_0 + w_{Ri} s_R + w_{Cj} s_C)/(w_0 + w_{Ri} + w_{Cj}). \quad [7]$$

Since the denominator varies from cell to cell of the design, the parallelism prediction will not hold. The deviations from parallelism will still show a systematic pattern, however, depending on the pattern of weight parameters. The expected form of the nonparallelism can be studied by using Equation 7 to determine how the difference between any two rows varies with column weight. The mathematical analysis is fairly straightforward but too detailed to include here.

To illustrate the matter, consider a square design for which the weights in row i and column i are equal. Suppose that the weights are arranged in increasing order of magnitude, from left to right across columns, and from top to bottom down rows. Finally, assume that w_0, the weight of the initial opinion, is zero. (The design provides a partial check on this last assumption, since it implies that the entries in every cell along the main diagonal are constant, equal to the simple mean value of the row and column communications. If w_0 is not zero, then averaging theory predicts a trend along the main diagonal from s_0 toward the mean of s_R and s_C.)

In this design, the global shape of the set of predicted curves is similar to a correlation ellipse, truncated at either end. Above the diagonal, the row curves converge to the right; below the diagonal, the row curves converge to the left. The overall trend is upward if the column communication has greater value, downward if the row communication has greater value. The magnitude of the trend depends on the difference between the values of the row and column communications. If these are equal, then the predicted response is the same in all cells.

A simple experimental realization of this illustrative design would be available with the personality-impression task. The row and column communications would correspond to two sets of personality-trait adjectives describing a single person. Weight could then be manipulated by specifying the occupations of the sources (Rosenbaum & Levin, 1968, 1969), for instance, or by otherwise varying the reliability of the information.

Application 3

Under the averaging hypothesis, Equation 5 becomes

$$R_{ij} = (w_0 s_0 + w_{Ri} s_{Cj})/(w_0 + w_{Ri}). \quad [8]$$

If w_0 is zero, then R_{ij} equals the scale value of the communication regardless of the source weight. This might seem odd, but with no other basis for opinion, the communication must be taken at face value. Since this case is mathematically trivial, it will be assumed that w_0 is not zero.

The analysis under the averaging hypothesis parallels that of Application 3 above except in one respect. If Equation 8 is averaged over rows, the marginal column means are a linear function of the communication values. In practice, this means that the observed column means may be used as provisional estimates of the scale values in the bilinear test of fit. To the degree that the model is validated, the column means may be considered as interval scales of the communication values.

The one change required by the averaging constraint comes in the estimation of the weight parameters. In the simple multiplying model, the slopes of the bilinearized curves are proportional to the weights, w_{Ri}; with the averaging constraint, they are proportional to $w_{Ri}/(w_{Ri} + w_0)$.

Application 4

Only one case of Application 4, one that has considerable importance, will be considered in detail. The model for this case may be written,

$$R_{ij} = (w_0 s_0 + w_R s_{Ri} + w_{Cj} s_{Cj})/(w_0 + w_R + w_{Cj}). \quad [9]$$

This is the averaging form of Equation 6 under the added restriction that the row weight is constant.

Figure 2 illustrates the difference between the adding and averaging models. These plots are for a 3 × 4 design for which the communication scale values are those listed in Table 1B. The left panel is calculated on the assumption that the row and column weights both equal one. These three curves are parallel. The right panel is calculated on the assumption that the row weight is one, but that the column weight increases with scale value as specified in the figure legend. These curves are not parallel.

Despite this nonparallelism, the right panel of Figure 2 shows two regularities. The first is qualitative: the curves converge

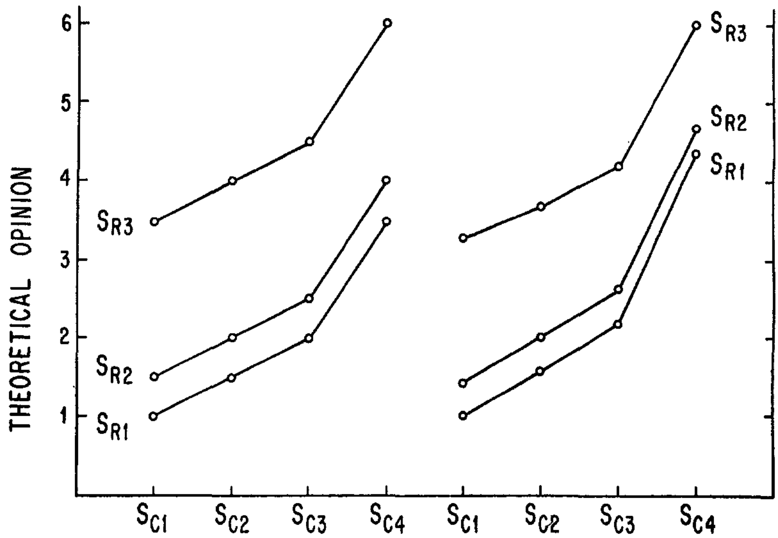

FIG. 2. Illustration of parallelism prediction with equal weighting in left graph, nonparallelism with unequal weighting in right graph. (Each point is the predicted opinion resulting from two communications whose scale values are given in Table 1B. In the right graph, the weight of the row communication is 1, while the weight of the column communication increases with scale value according to the formula, $1 + .2s_{Cj}$.)

toward the right, that is, as the scale value increases. This illustrates a general convergence prediction of the differential weighting model: Whenever the weights of the informational stimuli are directly related to their magnitudes, this same convergence pattern will be obtained. If the design were extended to include stimuli with negative values, this pattern would reappear as a convergence from the middle toward the left. Bilateral asymmetry would reflect differential weighting of positive and negative stimuli.

The second regularity in the right panel of Figure 2 is quantitative; the difference between any two row curves is a constant multiple of the difference between any other two row curves. This can be seen more readily by reference to Equation 9. The difference between the first two rows is

$$R_{2j} - R_{1j} = w_R(s_{R2} - s_{R1})/(w_0 + w_R + w_{Cj}). \quad [10]$$

If the difference between the first and third rows is expressed similarly, the ratio of these two differences is

$$(R_{2j} - R_{1j})/(R_{3j} - R_{1j}) = (s_{R2} - s_{R1})/(s_{R3} - s_{R1}), \quad [11a]$$

which is constant, independent of columns. Equation 11a can thus be rewritten,

$$(R_{2j} - R_{1j}) = a(R_{3j} - R_{1j}), \quad j = 1,2,\cdots, \quad [11b]$$

where a is a constant. This result holds in general so that any two sets of row differences should plot as straight-line functions of each other. This property could be used as a rough graphical test of fit.

Another graphical test, somewhat simpler, can be obtained by plotting the entries in each column as a function of the row means. The model implies that each column should plot as a straight line except for sampling error.

An interesting extension of bilinearity analysis (Anderson, 1970a, p. 157) provides an exact statistical test. The computing procedure given there may be followed exactly with these modifications. First a reduced data matrix is obtained by subtracting the column mean from all entries in each column. This has the effect of reducing Equation 9 to the form of a simple multiplying model. All further calculations are done in terms of this reduced matrix. The comparison coefficients for rows are just the row means, since the grand mean is zero. To get the comparison coefficients for columns requires a detour, since all column means are zero in the reduced matrix. For this purpose only, the sign of all cell entries is ignored; the column comparison coefficients are then obtained as in the cited reference as column deviations from the grand mean in this temporary matrix of absolute values. These comparison coefficients allow calculation of the Linear $\times$ Linear component of the interaction. The residual interaction should then be nonsignificant. Its *df* equals $(r - 2)(c - 1) - 1$, where r and c are the number of rows and columns; the initial reduction of the data matrix loses one degree of freedom per column through estimating an additive constant in each column.

The error term requires a brief comment. The within-cells error would be used for both the Linear $\times$ Linear component and the Residual interaction for the case of independent groups in each cell and, typically, for single subject analysis as well. Repeated-measurements designs, with each subject in all conditions, are more complicated. If the analysis is to be made over subjects, the above procedure needs to be applied to each subject. The overall Row $\times$ Column interaction is split into Linear $\times$ Linear and Residual components using the means of the individual comparison coefficients. In parallel, the Subject $\times$ Row $\times$ Column interaction is split into Subjects $\times$ Linear $\times$ Linear, and Subjects $\times$ Residual. Each component of the overall interaction is then tested against its interaction with subjects.

Two functional scales are also available. If Equation 9 is averaged over columns, it becomes a linear function of the row scale value, s_{Ri}. As in Application 1, the row marginal means provide an equal-interval scale of the values of the row communications.

Furthermore, Equation 10 indicates that the row difference is an inverse measure of the column weight, w_{Cj}. Thus, the reciprocals of the row differences can provide an interval scale of the column weight parameter as shown in Equation 12:

$$w_{Cj} = -(w_0 + w_R) + w_R(s_{R1} - s_{R2})/(R_{1j} - R_{2j}). \quad [12]$$

The optimal statistical procedure for estimating these weights is not known, however.

Differential Weighted Averaging

In the application just considered, the weight parameter was allowed to vary arbitrarily as a function of the scale value. There is increasing evidence that such differential weighting is more the rule than the exception (Lampel & Anderson, 1968; Oden & Anderson, 1971), and differential weighting seems especially likely in attitude change experiments. It is fortunate, therefore, that some direct analyses and estimation methods are possible.

The importance of this result can be illustrated by the date ratings of Lampel and Anderson (1968) which illustrate that a cognitive interaction of some complexity can be handled simply. Boys described by a photo and two personality-trait adjectives were rated as coffee dates by college girls. The data provided a critical test of averaging–adding in favor of averaging. In addition, the Adjective × Photo interaction was very large, with the adjectives having a greater effect with a positive than with a negative photo. This was interpreted as a discounting effect: girls do not want to be seen dating unattractive boys no matter how nice they are; as their physical appearance improves, their personality characteristics become more important. In theoretical terms, then, the weight of the photo is inversely related to its value.

In this experiment, the adjectives correspond to the rows, the photos to the columns of Application 4. Figure 1 of the cited article plots two difference curves analogous to Equation 10. The upper curve is almost exactly a constant multiple of the lower curve, in agreement with Equations 11a and 11b.

Conjunctive and disjunctive models (e.g., Coombs, 1964; Torgerson, 1958) can also be represented as differential weighted averaging models. The standard conjunctive model sets a criterion on each of several dimensions. Only if the criterion is exceeded on all dimensions simultaneously is a positive decision made. The present approach would replace the criterion by a weighting function that had high weights below some threshold region, diminishing to lower weights at higher levels of the scale value. Because the averaging model requires the weights to sum to one, any stimulus variable that fell below the criterion could dominate the response and prevent a positive decision. The averaging model thus provides a more general and flexible analysis. In particular, it replaces the somewhat artificial point criterion by a band or region.

It should also be noted that scaling is an integral part of psychological theory in the present approach. The standard treatments of conjunctive and disjunctive models, in contrast, assume that stimulus scale values are already at hand. But if weight and scale value are inversely related, as in the date-rating experiment, this critically affects the scaling analysis.

It has been suggested that a strict adding model should have been applied to the main data of the date-rating experiment. The observed interactions then would be interpreted as an artifact of a merely ordinal response scale, to be eliminated by appropriate monotone transformation (Anderson, 1962b; Bogartz & Wackwitz, 1970; Kruskal, 1965). This same argument holds more generally for the averaging analysis of Application 4. A convergence interaction could reflect a nonlinear output function (Bogartz & Wackwitz, 1970, 1971) rather than a real averaging effect. Because of their simplicity, strict adding models have been favorites in abstract measurement theory, and they have many mathematically convenient properties. However, the empirical evidence summarized under Averaging versus Adding above raises considerable doubt about the validity of strict adding models.

RELATIONS TO OTHER THEORIES

This section compares integration theory with several other theories of attitude change, mainly those that have attempted some degree of quantitative analysis. The main purpose of these comparisons is to show how integration theory handles various traditional problems in attitude theory.

Balance Theory

As an organizing concept, a principle of information integration has certain advantages over the principles of balance and congruity (Anderson, 1968a). Critical comparisons by Lindner (1970, 1971) have supported integration theory. This section will illustrate the theoretical comparison in more detail. Since the most extensive attempt to relate balance theory to attitude change is that of Feather (1964, 1967), only his development will be considered here. A recent review of balance theory is given by Zajonc (1968). Mention should also be made of the work of Wiest (1965), who has attempted to quantify the strengths of the relations, and of Newcomb (1968), who has attempted to give a more realistic definition of balanced states.

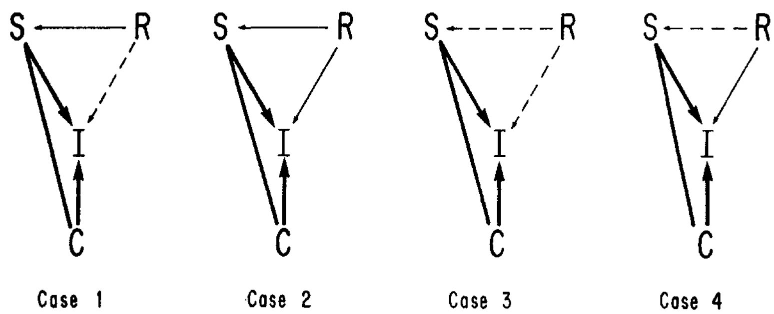

FIG. 3. Communication graphs, with S, C, I, and R denoting Source, Communication, Issue, and Receiver. (Solid lines denote a positive association or attitude; broken lines denote a negative attitude.)

Feather bases his analysis on the graph diagrams studied by Cartwright and Harary (1956) and illustrated in Figure 3. The solid arrow connecting C to I means that the communication (C) is favorable toward the issue (I) in each of the four cases. Similarly, the solid arrow connecting S to I means that the receiver (R) considers the source (S) to be favorable toward the issue prior to receiving the communication. The solid line connecting S to C simply means that the communication comes from the source. The initial attitudes of the receiver toward the issue and the source are denoted by s_0 and I_0, respectively. These features are the same in all four diagrams.

Attitude toward issue. For each diagram in Figure 3, the receiver gets two pieces of information about the issue: the initial stand of the source and the favorable communication from the source. For simplicity, it will be assumed that the prior stand of the source has already been integrated and become part of s_0. The integration equation for the attitude after receipt of the favorable communication is then

$$s = w_0 s_0 + w_1 s_C, \qquad [13]$$

a weighted sum or average of the initial attitude, s_0, and the scale value of the communication, s_C. The effective weight, w_1, of the communication will depend on properties of the source and communication as discussed elsewhere.

The four cases in Figure 3 differ according as initial attitudes of the receiver toward the source and issue are positive (solid arrow) or negative (broken arrow). These will now be discussed in turn.

Case 1: Here the receiver's initial attitude is positive toward the source, negative toward the issue. Figure 3 then represents an unbalanced structure, and balance theory postulates a tendency to restore balance. In integration theory this tendency is not a postulate but a deduction. In Equation 13, s_0 is negative, because the initial attitude toward the issue is negative, but both w_1 and s_C are positive. Accordingly, Equation 13 implies directly that the postcommunication attitude will be less negative, perhaps even positive.

This is no more than common sense, of course, but integration theory differs from balance theory in two important ways. First, the final state need not be balanced; the postcommunication attitude may be predictably negative. Second, integration theory allows a quantitative analysis of the magnitude of attitude change and its dependence on various stimulus parameters. It thus takes into account the strengths of the relations which balance theory is unable to handle satisfactorily.

Case 2: Here the receiver's initial attitudes toward source and issue are both positive. Since there is no imbalance in the diagram, balance theory has no basis on which to predict a change in attitude.

Integration theory does predict a change, following Equation 13. Under the averaging model, moreover, the changed attitude will be more positive or less positive, according as s_C, the communication value, is more or less positive than s_0, the initial attitude.

Case 3: Here the receiver is initially negative toward source and issue both as indicated by the broken arrows in Figure 3. Since the SRI triad is balanced, balance theory again lacks a basis on which to predict a change in attitude.

Under integration theory, the theoretical analysis depends on whether w_1 is positive or negative. That w_1 may be positive even with a negative source is indicated by the positive attitude change found with low credible sources (see Hovland et al., 1953; McGuire, 1969). If w_1 is positive, then the receiver's attitude toward the issue will become less negative. Indeed, it may even become positive, thus converting a balanced state to an imbalanced state.

Case 4: Here the receiver has a negative attitude toward the source but is positive toward the issue. This unbalanced state could become balanced if either the receiver adopted a positive attitude toward the source, or else a negative attitude toward the issue. Balance theory does not predict which will occur.

For integration theory, the theoretical analysis again depends on whether w_1 is positive or negative. If w_1 is negative, the receiver's attitude toward the issue will become less positive, and hence more balanced. However, if w_1 is positive, then the receiver's attitude toward the issue becomes even more positive, increasing the imbalance. As in Case 3, this allows a critical qualitative test between balance theory and integration theory.

Attitude toward source. Integration theory analyzes attitude toward the source in much the same way as just illustrated for attitude toward the issue. In the diagrams of Figure 3, there are three relevant informational stimuli, including the receiver's prior attitude toward the source. Thus, the communication attributed to the source constitutes a piece of information about the source; as such it has a certain weight and scale value. The same holds for the initial stand attributed to the source. Both these pieces of information are then to be integrated into the receiver's initial opinion about the source, and the integration process is assumed to be essentially the same as for the issue.

There are, however, important differences in detail, especially in the valuation process, that reflect the asymmetry of the source-issue relation. That the source favors the issue does not mean that the issue favors the source, for instance. In addition, the valuation process will depend on the dimension of judgment. In particular, the parameters of the informational stimuli will be different if the receiver judges the position of the source on the issue than if he makes an evaluative judgment of the source.

Evaluation of the communication. Judgments of the communication, such as its position on the issue, or its fairness, will of course depend in detail on the content and structure of the communication. They will also, as is well known, depend on the attitude of the receiver and his valuation of the source, and this dependence will be discussed briefly.

If the receiver is asked to judge the position of the communication on the issue, he has two main pieces of information to rely on. One is his opinion, explicit or inferred, about the source's stand on the issue independent of the communication. The other is the content of the communication per se. Under the simplest theoretical analysis, the judgment of the communication will then be a weighted average of these two pieces of information. Loosely speaking, the judgment might be considered a compromise between what the source actually said and what the source was expected to say; certainly this is a reasonable strategy from the subject's view.

From this standpoint, the theoretical analysis of the communication parallels that just given for judgments of the issue. For instance, if the initial attitude toward the source is negative, the communication will ordinarily be seen as less positive when attributed to the source than when considered alone. Here as before, a tendency toward balance arises as a deduction from integration theory.

This simple averaging analysis does not allow for the seeming fact that the judged position of a communication may also depend on the receiver's attitude toward the issue. This is a complicated problem (see Kiesler, Collins, & Miller, 1969, pp. 264 ff.) that will be briefly considered under Assimilation-Contrast Theory, below.

Judgments of the fairness or plausibility of the communication have also been considered (see, e.g., Brigham & Cook, 1970; McGuire, 1969). The general finding is that communications more discrepant from one's own position tend to be judged as less fair. This commonsense result merits a commonsense explanation: if the receiver is at all attached to his own position and considers it correct, he will naturally judge a discrepant communication as incorrect, hence misleading, and hence unfair. At the same time, many experimental studies of opinion change do not involve firm opinions, and in such cases fairness would not necessarily be affected. Thus, it seems more promising to look for a social learning base for such evaluations rather than a principle of balance.

Summary comments. The main conclusion from the preceding analysis is that a tendency toward balance may be derived from a principle of information integration.

Further, the integration principle is more general since it also accounts for opinion change in balanced situations. Only certain illustrative situations have been considered, of course, but much the same analysis would seem to apply to the numerous other graph structures considered by Feather (1967).

Integration theory has additional advantages. Feather (1964, 1967) has noted that major unresolved problems in balance theory include allowing for the strengths of relations, for the importance of the issue, as well as for individual differences. These problems are handled in a natural way, in terms of the w and s parameters of integration theory. Moreover, functional measurement technique is specifically oriented toward measurement at the level of the individual.

Heider (1958) has stated that "Formulation in terms of equifinality [balanced end state] is more parsimonious than formulation in terms of single conditions and effects [p. 207]." Integration theory takes the opposite road to parsimony, stressing the primary importance of detailed analysis, both theoretical and experimental, of stimulus conditions and their effects.

Congruity Theory

Congruity theory (Osgood & Tannenbaum, 1955; Tannenbaum, 1967, 1968) postulates an averaging model of the form of Equation 1 (S. Rosenberg, 1968). It is, however, a very specialized averaging model, since it requires the weight parameters to be specific functions of the scale values or polarities of the stimuli. For two stimuli of values s_1 and s_2, congruity theory postulates that $w_1 = |s_1|/(|s_1| + |s_2|)$, $w_2 = |s_2|/(|s_1| + |s_2|)$. This formulation makes the weight increase with the scale value, which would be reasonable in many situations. It also requires a neutral stimulus to have zero weight, which is clearly wrong.

In the present formulation, the weight parameter can depend on factors other than stimulus value. For instance, one can experimentally manipulate the credibility or reliability of the information without thereby affecting its scale value. This indicates that congruity theory has an inadequate conceptual base. Moreover, congruity theory has not been able to handle the set-size effect, in which the addition of information of equal value increases the extremity of the response (e.g., Anderson, 1959a, 1965a, 1967). An extensive discussion of this and related problems is given by Smith (1970).

Tannenbaum (1967) has recently discussed two experiments that he interprets to support congruity theory and to infirm an information-processing approach. However, both experiments can be treated as 2×2 designs for which integration theory predicts zero interaction, in agreement with the data. An earlier experiment by Tannenbaum and Norris (1965) also showed a nonsignificant interaction, though there the theoretical analysis is less clear.

In one experiment (Tannenbaum, 1967, Table VI), each condition contained one message from a positive source, one message from a negative source. The four conditions differed in that they contained two positive messages, two negative messages, or one of each polarity. The interaction term would apparently not have approached significance, in agreement with integration theory. The data imply a negative weight for the negative source, though this may reflect the covariance adjustment.

In the other experiment, the four experimental conditions received either the same or different messages, from either the same or different sources. In an informational analysis, redundant information requires a redundancy parameter, in this case for same-versus-different message as well as for same-versus-different source. These redundancy parameters need not be evaluated, but can be incorporated directly in the formal model. The adding model then predicts zero interaction, and the averaging model makes approximately the same prediction. Tannenbaum's data (1967, Table V) show a very small interaction term that would evidently not have been significant.

Neither experiment, therefore, poses any difficulty for information integration theory. Indeed, integration theory goes beyond congruity theory to make quantitative predictions in both cited experiments.

Integration theory implies that congruity, like balance, will generally increase. A congruity principle, or at least a congruity tendency, is thus a deduction from a more general principle of information integration. The detailed supporting analysis for this claim has already been given in the discussion of balance theory. Here it may be noted that integration theory avoids a fundamental criticism raised by Abelson (1963). If a positive source makes a positive statement about some issue, the evaluation of source and issue will approach each other. The cause, according to congruity theory, is a pressure toward congruity which exists as long as the source and issue evaluations are unequal. This makes it awkward to explain why complete congruity is seldom if ever obtained. For integration theory, there is no difficulty. The change is effected by the information in the communication; once this is absorbed, no further change is implied and there is no reason to expect complete congruity between source and issue.

Assimilation-Contrast Theory

The present theory of opinions and attitudes is in large part a theory of social judgment. Although this section is meant to compare integration theory with other quantitative formulations, comparison with assimilation-contrast theory (Sherif & Hovland, 1961; Sherif, Sherif, & Nebergall, 1965) is appropriate since it also emphasizes judgmental processes. Summaries and evaluations of their theory have been given by Insko (1967) and Kiesler et al. (1969). Here the two approaches will be compared in the context of an interesting recent experiment by Rhine and Severance (1970).

Rhine and Severance studied three variables: source credibility, ego involvement, and discrepancy between the person's initial attitude and the position advocated by the communication. For a single communication with weight w_1 and value s_1, the postcommunication attitude can be written as

$$R = w_0 s_0 + w_1 s_1, \qquad [14]$$

where s_0 is the initial opinion, with weight w_0. In an averaging model, the weights are required to sum to one. This effect can be achieved by letting w_1, and $w_0 = 1 - w_1$ be the relative weights. Then Equation 14 can be rewritten as

$$R = s_0 + w_1(s_1 - s_0). \qquad [15]$$

From Equation 15, the change in attitude is seen to be just $w_1(s_1 - s_0)$. Accordingly the theoretical analysis devolves on the determinants of w_1 and of $(s_1 - s_0)$.

Source credibility will affect w_1. A more credible source would correspond directly to a larger value of w_1 and would produce more attitude change.

Ego involvement was defined by choice of issue, either the proposed tuition increase in the University of California, Riverside, where the experiment was run, or the desired size of the city park in Allentown, Pennsylvania. For this particular manipulation, ego involvement corresponds to w_0, the strength of the initial opinion. Thus, w_1 would be lower for the higher level of ego involvement and less change would occur.

The discrepancy variable, $(s_1 - s_0)$, was manipulated by using three different dollar or acre values in the communications given to different groups. With no further qualification, Equation 15 predicts that amount of opinion change will be a linear function of the discrepancy, $(s_1 - s_0)$. This was found to hold for the parks issue though not on the tuition issue.

Integration theory includes a process of inconsistency discounting (Anderson & Jacobson, 1965) in which inconsistent information is given decreased weight. For example, a communication attributed to a highly credible source would tend to be discounted if it was inconsistent with the person's previous opinion about the source's position. In the same way, a communication will tend to be discounted when it is inconsistent with fact or with the person's own previous opinion on the given issue.

Accordingly, the predicted effect of the discrepancy variable needs to be considered in the light of the experimental task. For the parks issue, the subjects were told that the average park size was 20 acres for a city with a little less than half the 106,400 population of Allentown. The highest advocated figure was 240 acres which would not be expected to evoke any inconsistency reaction. On that basis, the obtained linear relation between advocated change and obtained change is in accord with expectation (Anderson, 1959a; Anderson & Hovland, 1957). Theoretically, linearity is a direct consequence of the averaging hypothesis.

The highest advocated increase in tuition was $600 which was very high, especially in view of the long tradition of free tuition that prevailed prior to the present state administration. For the tuition issue, w_1 would decrease as $(s_1 - s_0)$ increased. The predicted change, being the product of these two factors, would accordingly increase at first and later decrease as s_1 became more discrepant from s_0.

The inverted-U relation obtained for the tuition issue by Rhine and Severance, as well as similar results obtained by others (e.g., Aronson, Turner, & Carlsmith, 1963; Bochner & Insko, 1966), is thus consistent with integration theory. It should be noted, however, that a firm prediction of the later decrease depends on having sufficiently large values of the discrepancy variable. Rhine (personal communication, 1970) has suggested that this was the case on the ground that the discrepancies extended well into the latitude of rejection.

In their Table 5, Rhine and Severance list five predictions about attitude change and conclude that assimilation-contrast theory accounts for three of these while dissonance theory accounts for two. Integration theory, on the analysis just given, agrees with the data in all five cases. This analysis is post hoc, of course, but it is not ad hoc; no special assumptions were made in applying the integration model. Rhine and Severance also provide data on source and message evaluation that may be analyzed in the manner indicated in the section on balance theory.

Inconsistency discounting is central in the present analysis of the discrepancy variable. Almost all other theories of attitude change postulate some process that has the same general effect (see Insko, 1967, Ch. 3). None of these is too satisfactory, since their application depends more or less on common sense. Integration theory has one advantage, since it can make definite quantitative predictions about the effects of combining two communications.

The heavy dependence of the Sherif-Hovland approach on concepts of assimilation and contrast is of theoretical concern for several reasons (see Insko, 1967; Kiesler et al., 1969; Upshaw, 1969). Assimilation-contrast is considered again later, and only two points will be made here. Both bear on a problem mentioned in the discussion of balance theory; namely, the effect of a person's own opinion on his judgment of the position of a communication.

Sherif and Hovland claim that people with strong opinions tend to see communications that portray markedly different opinions as even more discrepant than they "really" are, a contrast effect. Such claims are beset by interpretational difficulties. Defining the "real" position of the communication in terms of responses of other people is a dubious procedure. Within functional measurement theory, the scale value of the communication is unique to each person; that one person's evaluation differs from that of another does not mean that either has distorted the position of the communication. This view is consistent with Upshaw's (1965, 1969) explanation in terms of a variable zero point in the judgment scale. In general, comparisons between different populations can be most difficult (Anderson, 1963), and this is no less true when the populations are single people.

It is also possible that such displacement effects represent composite judgmental processes. For example, the overt judgment of the communication may be a weighted average of its position on the issue, and of the felt position, or perhaps of the social evaluation of the person to whom the statement is attributed. For many political and social issues, such a judgmental process would appear to produce "contrast" for positions far from that held by the judge, and "assimilation" for positions near that held by the judge. On this basis, apparent contrast in evaluation of discrepant communications would be expected from Dawes' (1971) finding that persons with opposite points of view are thought to be more extreme than they are in fact. A related model for an assimilation effect has been applied to component judgments in impression formation with some success (Anderson, 1966a; Kaplan, 1971).

Similarity-Attraction Model

An extended series of experiments by Byrne and his associates (see Byrne, 1969) has supported, under certain experimental conditions, the hypothesis that interpersonal attraction is a linear function of proportion of similar attitudes. In the typical experiment, the subject receives a form purporting to describe the attitudes of a stranger on political affiliation, drinking, and similar issues. These forms are constructed to have specified numbers of attitudes that are similar and dissimilar to the attitudes of the subject. The subject's response is a rating of how much he would like the stranger.

This interpersonal attraction task is quite similar to the personality-impression task studied by the writer (Anderson, 1967; Byrne, Lamberth, Palmer, & London, 1969). It is appropriate, therefore, to ask how integration theory might apply to the interpersonal-attraction task. Of the numerous interesting results, only one or two can be considered here.

From the view of information integration theory, each item on the form constitutes a piece of information about the stranger, much the same as a trait adjective. As such, it has a weight and a scale value along the dimension of judgment. Let w_p and s_p be the weight and value of an item marked similar, and let w_n and s_n be the weight and value of an item marked dissimilar. Suppose there are N items altogether of which k are marked similar. Under the adding model, the theoretical expression for the attraction response is then

$$R = kw_p s_p + (N - k)w_n s_n. \qquad [16]$$

If the number of items marked similar is increased by one, k would be replaced by $k + 1$ in this equation. The change in response is then the difference,

$$\Delta R = w_p s_p - w_n s_n. \qquad [17]$$

Since ΔR does not depend on k, it follows that R is a linear function of k, and hence also of k/N, the proportion of similar items. Under the given assumptions, therefore, Byrne's linearity result is consistent with prediction from integration theory. More direct empirical support has been obtained by Kaplan and Olczak (1970) who employed a factorial integration design as in Application 1.

The adding model of Equation 16 rests on the assumption that the similar items have equal value and weight, and so also for the dissimilar items. If these assumptions do not hold, the linearity prediction does not follow. However, it would still be possible to use Application 4 of the adding model to get a parallelism prediction.

If the averaging model holds, the right side of Equation 16 must be divided by the sum of the weights, $kw_p + (N - k)w_n$. The linearity prediction then holds only if $w_p = w_n$. Deviations from linearity would then be expected to the degree that similar and dissimilar items are differentially weighted. This possibility deserves further consideration since the personality-trait studies argue for an averaging model.

Two important differences between integration theory and Byrne's formulation can be illustrated in the Byrne and Rhamey (1965) experiment. In addition to the information about the stranger's own attitude, the subjects also received information about the stranger's evaluation of the subject's own intelligence, adjustment, etc. To handle two sources of information, the attraction equation was modified so that

> attraction toward X is a positive linear function of the sum of weighted positive reinforcements (Number $\times$ Magnitude) received from X divided by the total number of weighted positive and negative reinforcements received from X [Byrne & Rhamey, 1965, p. 887].

This differs from the integration model in several respects. For instance, the scale values, which correspond to their "reinforcements," do not appear in the denominator of the integration equation.

The Byrne and Rhamey experiment has special interest, since it employed a two-way design in which the interaction was significant, contrary to the simple integration model. Inspection of their data suggests that the interaction results from a discounting of the attitude-similarity information in the context of the favorable evaluation of the subject. The value of their control condition in supporting this interpretation deserves particular mention as a useful methodological device.

It should be noted that Byrne and Rhamey also predict no interaction (see Table 5, Byrne & Rhamey, 1965). That they got a close fit to the linear function despite the interaction illustrates the limitations of regression analysis discussed in the next section.

The second difference between integration theory and Byrne's formulation is more fundamental. As illustrated in the above quotation, Byrne considers the attitude-similarity items to be reinforcing stimuli. Integration theory considers them to be informational stimuli, a view that is supported by the work of Himmelfarb and Senn (1969) on judgments of social class.

This distinction between informational stimuli and reinforcing stimuli would hold no less in real social situations. From the present view, giving praise or blame does not necessarily act as a reinforcing stimulus for the attraction response to the source; it may simply provide an informational stimulus which is integrated into the opinion about the source. In applications to learning (Anderson, 1969b; Anderson & Hubert, 1963; Friedman et al., 1968), integration theory thus appears as a cognitive, information-processing theory somewhat in the sense of Tolman rather than an S–R reinforcement theory in the sense of Hull or Skinner.

Summation Theories

Certain kinds of integration tasks evidently require strict adding rather than averaging models. For example, the value of a commodity bundle might be taken as the sum of the values of its components (e.g., Bock & Jones, 1968; Gulliksen, 1956), possibly with a law of diminishing returns (Shanteau, 1970b). The addition of one commodity to the bundle would thus increase the total value. For attitude change also, an adding process is intuitively attractive, on the analogous argument that the addition of favorable information should increase the favorableness of the response.

The most vocal attempt to support an adding model for attitude change has been made by Fishbein and his associates. Triandis and Fishbein (1963) used a personality-impression task to compare a summation model with congruity theory. Mean correlations between observed and predicted were .65 for the summation model, .53 for congruity theory. Two later experiments (L. R. Anderson & Fishbein, 1965; Fishbein & Hunter, 1964), also on personality impression formation, showed similar support for a regression model over the congruity model.

For some reason, this disconfirmation of congruity theory was generalized to include all averaging models on the one hand, and all balance-consistency theories on the other. But congruity theory is a very specialized averaging model as already noted. Moreover, general balance theory carries no commitment to adding or averaging (Abelson, 1968a, p. 123; Anderson 1968a). M. J. Rosenberg (1968) also discusses this matter.

One further piece of evidence was given by Fishbein and Hunter (1964). With serial presentation of personality adjectives, they found that the addition of adjectives of essentially equal value increased the extremity of the response. This set-size effect contradicts the simplest form of an averaging model. However, essentially the same result had been obtained in previous work on attitude change (Anderson, 1959a) and was interpreted to result from the averaging in of an initial opinion. Later work has supported this interpretation (e.g., Anderson 1965a, 1967; Anderson & Alexander, 1971; Hendrick, 1968; Oden & Anderson, 1971).

It should be emphasized that a quantitative model can be used to good purpose in an essentially qualitative way as exemplified by the summation formulation used by M. J. Rosenberg and by Peak. Their means–ends formulation looks at the consequences or properties of an issue or object. Each consequence is considered to have a certain value for the person (analogous to the present s parameter), and also a "perceived instrumentality" (Rosenberg, 1960) or "judged probability" of occurrence (Peak, 1955) (analogous to the present w parameter). Attitude toward the issue or object is then simply Σws, an adding formulation that seems to be conceptually similar to that used by Fishbein (see Insko, 1967, pp. 136, 197). Rosenberg tested this formulation by using posthypnotic suggestion to change attitudes on certain issues, and found associated changes in the corresponding w and s values. Although this work has been criticized on the ground that hypnosis is even less understood than attitude change, there is no doubt about its great interest and potential.

Regression-Correlation Formulations

Much work on information integration, especially in clinical judgment, has rested on multiple regression and correlation analysis (e.g., Goldberg, 1968; Hammond, Hursch, & Todd, 1964; Hoffman, 1960; Meehl, 1954, 1960; Triandis & Fishbein, 1963; Tucker, 1960; Wishner, 1960; Wyer, 1969). This approach has suffered from two serious shortcomings.

In the first place, the correlation-regression analyses that are reported seldom include a test of fit of the linear regression model. It might seem that high correlations between predicted and observed are relevant evidence. However, very high correlations are virtually guaranteed by the usual experimental designs, even with a seriously defective model (Anderson, 1962a). Adequate assessment must attend to the discrepancies from the model predictions.

That discrepancies from an adding model can be important despite high correlations is illustrated in Sidowski and Anderson (1967). Subjects judged the desirability of working at certain occupations in certain cities. An adding model was applied, and the correlations between predicted and observed were .986 and .987 in two experiments; yet there was a sizable interaction localized at the occupation of teacher in the least desirable city. Similarly, the model-data correlation for the date ratings discussed above (Lampel & Anderson, 1968) was .985 despite a strong Adjective $\times$ Photo interaction. Even in an experiment designed specifically to produce a large configural effect (Anderson & Jacobson, 1965, Condition 2), the correlation was .977. In all these experiments, the discrepancy was clearly visible as a nonparallelism, and was readily picked up by the analysis of variance.

Thus, the present approach leads to a different view from that of Goldberg's (1968) review of linear models in clinical judgment. Goldberg considers three interpretations of the general finding that human judges are seldom better than linear prediction models, and suggests the most attractive interpretation to be that judges really behave configurally but that the linear regression model is so powerful that *it obscures the real configural processes*. The results cited in the previous paragraph, as well as related work, point to a fourth interpretation: A linear-type integration model holds in many situations, but there are certain conditions that produce configural response; further, analysis of variance has ample power to detect configurality when it occurs (Anderson, 1969a; Slovic, 1969).

The second difficulty with regression-correlation is more fundamental. Regression analysis typically proceeds under two scaling assumptions: that the stimulus values are known, and that the overt response is on an equal-interval scale. These assumptions naturally come under suspicion if the linear regression model does not fit well. Nonlinearity may be nothing more than an inappropriate stimulus scale. For if the ostensible stimulus scale is not equal interval, then a linear function of the true subjective values will appear to be nonlinear. Similarly, apparent configurality may not represent true interaction but only an inappropriate response scale (Anderson, 1961a, 1962b; Bogartz & Wackwitz, 1970). Without a theory of measurement to support the scaling assumptions, interpretations in terms of nonlinearity or configurality rest on uncertain ground. The advantage of functional measurement theory is that it gives a unified approach to these problems.

This brief discussion should not obscure the great usefulness of regression analysis in certain practical prediction problems.

As Yntema and Torgerson (1961) indicate, systematic discrepancies from a simple additive rule of combination may not be serious in certain man–machine systems. Much of the work on clinical judgment can be viewed from a similar standpoint of practical prediction. Unfortunately, there seems to be an overwhelming temptation to generalize from product to process, that is, from prediction to understanding. Good prediction does not imply good understanding, as the correlation coefficients quoted in the third paragraph of this subsection show. When the main concern is to understand the psychological processes that underlie the judgment, any systematic discrepancy may be meaningful and important.

It should also be emphasized that it is possible to apply regression analysis to the question of goodness of fit, as well as to the measurement question. Analysis of variance and multiple regression are both applications of the general linear hypothesis of mathematical statistics and have considerable similarity. However, the typical regression design corresponds to a highly confounded factorial design; therefore, discrepancies from prediction are generally difficult to localize and interpret. Moreover, nonindependence of the beta weights (Darlington, 1968) can complicate the stimulus scaling. On the other hand, regression designs can be very efficient, since they require far fewer observations than a complete factorial design. An attempt to apply multiple regression to attitude measurement has been made by Ramsay and Case (1970), though their approach assumes that the stimulus values are known and fails to supply a test of fit. Some work on extending functional measurement to regression analysis has been done by Bogartz and Wackwitz (1970, 1971).

Logical-Consistency Theory

That human reasoning does not obey formal syllogistic logic is well known. It is also well known that formal syllogisms are only a small part of logic, so perhaps human reasoning might accord with some more general logic model. This interesting possibility has been studied by McGuire in a series of articles (e.g., McGuire, 1960, 1968) on a logic model for probabilistic beliefs. The basic postulate is that subjective probabilities or beliefs must be consistent with one another in such a way that they obey the laws of mathematical probability theory, though they may otherwise have any relation to the objective probabilities.

McGuire has applied this logic model in both qualitative and quantitative ways. The qualitative approach assumes that the tendency toward logical consistency is complicated by other factors, such as wishful thinking, and is concerned with Socratic effects, cognitive structure, and related problems. The quantitative approach, which has been adopted by Wyer and Goldberg (1970) and Wyer (1970), assumes the basic postulate, that subjective probabilities obey mathematical probability theory, is exactly true. Only this quantitative approach will be considered here.

To facilitate comparison with integration theory, only the following law of probability theory will be considered:

$$P_B = P_A P_{B/A} + P_{A'} P_{B/A'}. \qquad [18]$$

Here P_A, $P_{A'}$, and P_B are the probabilities of A, not-A, and B; $P_{B/A}$ and $P_{B/A'}$ are the conditional probabilities of B, given A and not-A. The logical-consistency model does not require subjective probabilities to have any relation to objective probabilities (e.g., expectation of success need not equal its true probability). But it does require that subjective probabilities be consistent among themselves in the manner specified by Equation 18.

That one's beliefs on any given, restricted set of issues ordinarily exhibit a fair degree of consistency is a matter of common observation. But whether such a set of beliefs will obey Equation 18 of the logic model is not easy to determine. As a precaution, the investigation might be limited to belief systems that the person himself felt to be consistent. When some new fact or argument threatens a theoretical position, the belief system may be at least temporarily deranged.

Naturalistic observation. Testing the logic model in a naturalistic setting rests completely on the measurement of the subjective probabilities. If the five separate terms of Equation 18 can be measured, then it is fairly straightforward to test between P_B as observed and predicted. An absolute measurement scale is required, however, and it is unclear that the rating scales that have been used in the experimental work are even equal-interval scales. Shanteau (1970b) has found sizable differences between probability ratings of words such as *probably*, *unlikely*, etc., and their functional scale values. Correlation-regression analysis has the same shortcomings in this work that were discussed previously.

The use of ratings as measures of subjective probability seems especially problematic for the conditional events that occur in the logic model. The implication, "If abortion is infanticide, then it should be prosecuted like other murders," (if A, then B) presumably ought to get a high $P_{B/A}$ rating; but probably such ratings would be strongly affected in many people by their belief in the premise or the conclusion (Lefford, 1946; McGuire, 1968).

Equation 18, unfortunately, may be insensitive to such biases when the beliefs are extreme. If P_A, the belief in the premise, is near zero, bias in $P_{B/A}$ will have little effect. This illustrates that the logic model may yield reasonably good predictions even when it is seriously wrong. Of course, even if the ratings of the conditional events are not valid, that does not necessarily infirm the logic model. The person's internal cogitation may be perfectly consistent with Equation 18 without his being able to assign valid ratings to the events.

Two brief comments should perhaps be added on the use of such probability ratings. First, the processes that underlie such ratings may be of considerable interest and worth closer study in their own right. Second, there are many purposes for which an equal-interval scale is not needed. Random assignment allows comparison between different experimental treatments even with an ordinal scale (Anderson, 1961a, 1963). Similarly, McGuire's (1960) interesting work on the Socratic effect does not necessarily require an interval scale.

Experimental analysis. If integration theory can be applied to these probability judgments, a radical simplification of the measurement problem is possible. Accordingly, the blanket assumption is made that all five terms in Equation 18 follow this formulation. Since P_A, $P_{A'}$, and P_B presumably follow an averaging rather than an adding model, some care would be desirable to ensure equal weighting of the communications. For the two conditionals, $P_{B/A}$ and $P_{B/A'}$, a multiplying model would seem appropriate, though the overt ratings themselves might follow an averaging model.

The main question to be considered is whether the logic model and the integration formulation are mutually consistent. Application 1, in which two communications are given in a factorial design, will be used for this purpose. This reflects a key experimental change from the work of McGuire (1960) and of Wyer and Goldberg (1970); the use of two communications in a factorial design provides the leverage for a critical comparison.

Two cases need to be considered. The first case rests on the assumption that the communications have no effect on the conditionals, $P_{B/A}$ or $P_{B/A'}$, but only affect belief in A, A', and B. By assumption, these beliefs follow the integration model and substitution of the theoretical expression from Equation 2 into Equation 18 yields the following predictions for P_B:

$$P_{Bij} = (w_0 P_{A_0} + w_R s_{Ri} + w_C s_{Cj}) P_{B/A} + (w_0' P_{A'_0} + w_R' s_{Ri}' + w_C' s_{Cj}') P_{B/A'}. \quad [19]$$

This expression is additive in the manipulated scale values. The joint application of the logic model and integration theory thus implies zero interaction in these predicted values of P_B. Since this agrees with the assumption that the judgments of P_B obey the integration model, the logic model is consistent with integration theory in this case.

This test, it should be emphasized, can be made directly on the raw ratings of P_B. The problems of measuring the four terms on the right of Equation 18 have been completely bypassed. Furthermore, because of the response scaling feature of functional measurement, only an ordinal response scale is strictly necessary for judgments of P_B. This test does depend on getting communications that do not affect the conditional probabilities, but that should be straightforward, at least if the logic model is correct.

As the second case, suppose that one or both communications also affect belief in $P_{B/A}$ and/or $P_{B/A'}$. This could be arranged experimentally by an appropriate mixture of arguments. Equation 19 must then be changed by substituting in these theoretical expressions as well. This done, the predicted values of P_{Bij} no longer obey the parallelism prediction. This contradicts the original assumption that the averaging model applies to P_B. In this second case, therefore, integration theory and the logic model are inconsistent: if P_B obeys the averaging model, the logic model cannot hold.

Both cases are needed for a proper critical test. Although the first case does not distinguish between the models, it is necessary to show that at least one of the models may be correct. The personality adjective task has various advantages as an experimental situation. The conditional probabilities would then depend on the implicational similarity of the traits.

One essential difference between the two approaches is in the conceptualization of the attitude change process for P_B. In the integration model, the informational stimuli are considered to bear directly on P_B. In the logic model, these changes occur indirectly, mediated by changes in P_A, $P_{B/A}$, etc. In the logic model, the exact analysis of Equation 19 depends on whether $P_{B/A}$ and $P_{B/A'}$ follow an averaging, adding, or compound averaging–adding model, but some simple predictions about matrix rank are available.

Bayesian statistics. Modern developments in mathematical statistics have emphasized personal probability and Bayesian statistics (Edwards, Lindman, & Savage, 1963; Savage, 1957). The Bayesian approach has close parallels with logical-consistency theory. Part of its interest lies in its emphasis on the revision of statistical probability in the light of new evidence, analogous to opinion change. Although the Bayesian development is a strictly statistical theory, considerable experimental work has been done using it as a normative model of how men ought to process probabilistic information (see Edwards, 1968; Peterson & Beach, 1967; Slovic & Lichtenstein, 1970).

It is the fate of normative theories that men do not behave as they normatively ought. Aside from the ubiquitous order effects, the response is usually much more "conservative" than is statistically correct. Several explanations of "conservatism" have been given (Edwards, 1968), including misperception, misaggregation, and response bias.

In terms of integration theory, misperception and misaggregation would both correspond to weight parameters different from the statistically optimal values. Since integration theory is descriptive rather than normative, it is directly concerned with the determinants of the weights (Shanteau, 1970a). Nonoptimal weighting in the Bayesian binomial inference task would be no more surprising than in number averaging (Anderson, 1964d, 1968d), but deviations from a statistical standard, however important they might be in practical decision problems, seem unlikely to say much about psychological processes. In the present approach, accordingly, the emphasis is on getting a theoretical framework that is psychologically congruent to the behavior.

The response bias interpretation has recently been supported by DuCharme (1970). Of itself, response bias would not necessarily be serious, since the methods of functional measurement could be used to rectify a distorted response scale. However, the work of Shanteau (1970a) suggests a more fundamental response problem. The standard bookbag-and-poker-chip task used in the Bayesian research asks for inference judgments of the probability that there are more white than red chips in a population sampled one chip at a time. Shanteau compared such inference judgments with estimation judgments about the proportion of white chips in the population. No difference was found between these two conditions, and Shanteau's careful experimental work indicated that both instruction conditions produced estimation judgments. Shanteau's results may thus invalidate the Bayesian interpretation of the binomial inference experiments.

Proportional-Change Model

The proportional-change model for attitude change (Anderson, 1959a; Anderson & Hovland, 1957) postulates that the amount of attitude change is proportional to the advocated change:

$$s_1 = s_0 + w(s_C - s_0) = ws_C + (1 - w)s_0, \quad [20]$$

where s_0 and s_1 are the opinions before and after receipt of a communication with value s_C and weight w. An analogous postulate was used in learning theory by Hull (1943). An extensive mathematical development was given by Estes and Burke (1953) and Bush and Mosteller (1955) for discrete choice tasks, and by Anderson (1961b, 1964a, 1964b) and Rouanet and Rosenberg (1964) for continuous response tasks. In these models, the weight parameter represents the learning rate.

In its original form, the proportional-change model has not been very successful. In learning, the critical tests are the sequential dependencies (Anderson, 1959b; Atkinson & Estes, 1963). The failure of stimulus sampling theory of probability learning has resulted from its inability to account for these dependencies (see e.g., Anderson, 1960, 1964c, 1966b; Anderson & Grant, 1957, 1958; Anderson & Whalen, 1960; Friedman et al., 1968; Jones, 1971).

Attitude change experiments, in contrast to learning experiments, typically involve only a few "trials." As a consequence, the weight parameter will change over successive communications (Anderson, 1959a). A related difficulty arises in Abelson's (1964) generalization of the Anderson-Hovland model to group interaction situations which, under fairly general conditions, predicts that everyone in a given group will eventually reach the same opinion. This difficulty can be avoided if the communications are treated as informational stimuli. A given communication then loses its effectiveness over successive repetitions since it conveys no new information.

The present serial integration model includes the proportional-change model as a special case and has considerably greater flexibility. A principal advantage is its ability to allow for changes in the weight parameter over a sequence of informational stimuli. Complete serial position curves, which may include both primary and recency components, thus become available (e.g., Anderson, 1964d, 1965b; Shanteau, 1970a; Weiss & Anderson, 1969).

SOURCE AND COMMUNICATION PARAMETERS

The weight and value parameters are properties of the source-communication combination. Much work on attitude change is not concerned with source effects and there may not even be an explicit source. When paragraphs about United States Presidents are given as historical fact (Sawyers & Anderson, 1971), the concept of source is relevant, but it resides at large in the cultural-experimental context. At the other extreme, the source may be explicit and its nature an integral part of the communication.

The valuation problem is interesting in its own right, and it is also relevant to the various design applications that have been considered. The problem is complex, depending heavily on the situational details, and a brief discussion necessitates somewhat cavalier treatment. The following rough analysis should be useful in many cases and is given to illustrate some of the main points without explicit concern for its evident limitations.

Molar Analysis

To begin, it seems reasonable to expect that within limits the scale value will be independent of the source. There are important exceptions, of course, especially when the source is an integral part of the communication. In oral presentations, for example, warmth of voice and gesture could become attributes of the communication and affect its scale value. However, the scale value corresponds to the position of the communication on the issue. In a substantial part of attitude change research, this position is conveyed by the semantic content of the communication and should be independent of the source.

Determination of the weight parameter is markedly more complex as shown by numerous experimental studies summarized in McGuire's canonical chapter on attitude change (McGuire, 1969, pp. 177 ff.). Some communications, based on consistency or affective arguments, can have a completely source-free weight, but in most cases the weight will depend importantly on the source. The source may be merely implicit, defined by the cultural-experimental situation, or source weight may be explicitly varied. The weight will also depend on specific properties of the communication such as clarity and redundancy.

Both the source and the communication will thus contribute to the weight parameter. If these contributions are independent, as might be expected in some situations, it would be of interest to know how they combine. The most plausible hypothesis would seem to be a multiplying model, though a composite adding-multiplying model might prove necessary.

Of course, source and communication may interact with each other, and with the issue as well, in determining the weight parameter. A communication at variance with a source's known position on the issue might be partially discredited or discounted, that is, given a lower weight. Source expertise would also interact with the issue; an engineer would presumably be more effective on pollution control than on narcotics addiction.

Application 4 of the averaging model may be especially useful in the analysis of source effects and interactions. For example, a given communication could be attributed to different sources in different columns of the design. In each case, source and communication could interact in any way. The interval scale of the weight parameter would then provide an assessment of the source-communication-issue interactions as reflected in the weight parameter.

Molecular Analysis

Thus far, the communication has been treated as a unit with a single weight and scale value. However, it will usually have a more or less complex structure, containing various separate statements and arguments, and its molar effect will itself result from information integration. The following classification is neither novel nor complete, but it indicates how a molecular analysis might proceed.

Means–ends assertions constitute one great class of persuasive arguments (see McGuire, 1969, pp. 153 ff.). The source asserts that a certain action or belief will produce a good or avoid an evil, thereby modifying the acceptance of that action or belief. Each such argument is a subcommunication, and indeed a source-communication-issue instance. The issue is the good or evil end, and is the primary determinant of the value of the subcommunication. The weight parameter will reflect the importance of the end, and also the persuasive properties of the source and communication that link means and end. On this analysis, which is similar to that of Peak (1955) and Rosenberg (1956), each means–end argument counts as one piece of information to be integrated into the overall opinion.

The other class of persuasive arguments can be called inferences. Letters of reference, for example, are usually amplified lists of personality adjectives. To judge the intelligence or motivation of someone described as level-headed requires an uncertain inference about the parameters of the given information with respect to the specified dimension of judgment. Both weight and scale value would be determined primarily by the semantic-actuarial relations between level-headedness and intelligence or motivation. Source characteristics would also affect the valuation process of course.

Bare assertions by the source, "I disliked the movie," and "I consider Harry Truman one of the greater United States Presidents," have received considerable study as prestige suggestions. These may be considered inferences even though the inference may be a conditioned response of acceptance or rejection. Such statements have their weight determined by the source and their scale value by the semantic content of the assertion. With a design based on two prestige sources, Application 1 would provide a straightforward test of the integration model.

Consistency arguments may fall into both classes. "If you consider self-reliance a virtue, then you should allow your children more freedom" requires an assessment of the force of the implication. A means–end evaluation is also needed. Some consistency arguments are simple direct inferences, however.

This classification bridges the molar to the molecular. It is thus one approach to the detailed processing and integration of complex communications. Many communications will not stand a simple dissection, of course, but the total effect of those that do may be simple functions of the components. Suppose that $w_1, w_2, \cdots$, are the weights and $s_1, s_2, \cdots$, the scale values of the components of some communication. Averaging theory then implies that the scale value of the whole is the mean value of the parts,

$$s = \sum w_i s_i / \sum w_i, \qquad [21]$$

and that the weight of the whole is the sum of the weights of the parts,

$$w = \sum w_i. \qquad [22]$$

Equation 22 has interest as an adding rule within averaging theory. Inconsistency or redundancy among the components could affect their weights, of course. Theoretically, Equations 21 and 22 should still apply with these altered weights.

COGNITIVE CONSISTENCY

Cognitive consistency is central in attitude structure, and many current theories of attitude change take some consistency principle as their basic postulate and point of departure. The popularity of this approach is to be seen among the 84 chapters of *Theories of Cognitive Consistency: A Sourcebook* (Abelson, Aronson, McGuire, Newcomb, Rosenberg, & Tannenbaum, 1968). The variety, interest, and importance of the questions that have been raised by the consistency theorists are impressive.

But as the basis for a general theory of attitudes, a consistency postulate seems to be inherently inadequate. Much attitude change does not involve inconsistency resolution but only straightforward integration of information (Anderson, 1968a; Lindner, 1971). New information, including another's opinions and arguments, may alter attitudes and actions in the absence of any imbalance, incongruity, dissonance, or any other inconsistency. If this is correct, then a consistency principle is inherently too limited to support a general theory of attitudes. Just this limitation seems to be reflected in the conceptual insufficiencies of the various consistency principles, as well as in the problems that have arisen in attempts at quantitative treatment. Much of the difficulty seems to result from forcing the consistency principle into situations that do not involve inconsistency.

The present approach has developed differently, beginning with situations that do not require inconsistency resolution. The logic of this attack is straightforward. Inconsistency among the informational stimuli will affect their parameter values. The test of a simple averaging or adding model, though it requires some care, is straightforward if the stimulus parameters are constant. But if they vary across context, the analysis is markedly more difficult. It then becomes difficult to distinguish parameter changes from alternative integration rules. And it is also difficult to distinguish basic defects in the model from shortcomings in the experimental techniques.

The success of the averaging model with consistent information makes it possible to interpret deviations produced by integration of inconsistent information (Anderson & Jacobson, 1965). Moreover, success in the simpler situations helps validate the experimental techniques and the analytical procedures. The development of functional measurement theory, in particular, and the use of numerical ratings as equal-interval data have been central in this work. The support that this methodology has received in the simpler tasks provides part of the basis for attributing psychological meaning to discrepancies from the simple model in other situations (e.g., Lampel & Anderson, 1968; Oden & Anderson, 1971; Sidowski & Anderson, 1967; Slovic, 1969).

Inconsistency Resolution

Mechanisms for resolving inconsistency have been studied by numerous writers (e.g., Abelson, 1959, 1968b; Adams, 1968; Aronson, 1968; Feather, 1967; Festinger, 1957; Gollob, 1968; Hardyck & Kardush, 1968; Kaplan & Crockett, 1968; Kelman & Baron, 1968; McGuire, 1966, 1968; Weick, 1968). The present analysis has various similarities to previous treatments, though perhaps with some advantages in precision.

The most direct method of resolving inconsistency is in the valuation operation. If the informational stimuli are inconsistent, changes either in their meaning or in their importance could reduce the inconsistency. In the integration model, changes in meaning would be reflected as changes in s; changes in importance would be reflected as changes in w.

Attitude change experiments may explicitly or implicitly involve judgments of source and communication as well as the issue. The valuation process then becomes more complex as may be illustrated by considering an unpleasant communication attributed to a respected source. For the communication itself, the evidence below suggests that w will decrease but that s will remain constant. The decrease in w may result from revaluing the source or from inconsistency discounting, equivalent here to dissociating source and communication. At the same time, the communication constitutes a piece of information about the source. To the extent that it is not discounted, it will decrease the scale value of the source according to the analysis given in the section on balance theory.

Other mechanisms for resolving inconsistency will not be considered here, but it should be noted that the relation between valuation and integration needs closer analysis. The present discussion has implicitly viewed valuation as preceding integration. This is too simple a view: inconsistency can only exist as a consequence of an attempted integration. Valuation and integration must then proceed concurrently and a more molecular analysis is needed to delineate the temporal course of the total process.

Within the present framework, however, the two main modes of inconsistency resolution are change in meaning and change in weight. The evidence on these two modes will be discussed briefly to illustrate some of the problems.

Change of Meaning

The hypothesis that words change meaning as a function of context has great intuitive appeal. Certainly, it is true under certain conditions, as for words that have distinct alternative meanings (Anderson, 1968c). However, whether words with a single principal meaning change as a function of context is doubtful and certainly not well supported by existing data. Various lines of evidence have been considered, but none gives very convincing evidence for change of meaning in this case.

Evidence from primacy. One line of evidence that has received considerable study is the primacy effect in personality impressions first noted by Asch (1946). If good and bad traits are presented in serial order, the earlier traits have greater influence on the overall impression. Asch interpreted this in terms of change of meaning, as though the subject was selecting out those shades of meaning of the later words that would fit better with the earlier words (Anderson, 1965b; Asch, 1946). However, an extended series of experiments has provided little support for this view (see Anderson, 1965b, 1971a). Instead, it appears that the later adjectives keep a fixed scale value but get lower weight. Whether this results from discounting or attention decrement, however, is not yet completely clear (see Hendrick & Costantini, 1970).

In other work, Asch (1948) has argued that political statements change their meaning when attributed to different sources. These results, however, can be accounted for directly in terms of integration theory. It is only necessary to assume that the subject is attempting to judge the position of the source on the issue. For this he has two pieces of information: the statement itself and his prior opinion of the source's position. His judgment will be a composite or weighted average of these two informational stimuli and hence will vary directly with his opinion of the source. In this judgmental interpretation, it is not necessary to assume that the statement changes in any way.

Component judgments. Further support for a judgmental view comes from work on judgments of the single items of a combination. If subjects are asked to judge the likableness of each separate trait in a person description, there is a positive context effect: the rating of each trait shifts from its context-free value toward the values of the other traits (Anderson, 1966a; Anderson & Lampel, 1965). The obvious interpretation is that these judgments directly reflect change in meaning. Beyond plausibility, there is no satisfactory evidence for change of meaning, and the alternative hypothesis of a generalized halo effect is equally plausible. The available evidence (Anderson, 1971a; Kaplan, 1971) supports the judgmental view.

Contrast and assimilation. The concepts of contrast and assimilation have been widely but uncritically used in social psychology. Such effects, if real, would correspond to changes in meaning or scale value Assimilation, however, may result from composite judgmental processes as already suggested, and it is well known that contrast effects may be artifacts of the response language rather than changes in stimulus value. Even with psychophysical stimuli such as lifted weights, contrast effects are not always obtained (Anderson, 1971b; Schiffman, Goldstein, & Aroksaar, 1970).

The problem of contrast with verbal stimuli has been considered by numerous workers (e.g., Anderson & Lampel, 1965; Campbell, Lewis, & Hunt, 1958; Dawes, 1971; Manis, 1971; Parducci, 1965; Segall, 1959; Upshaw, 1965). It seems clear that most observed contrast effects stem largely from response language usage, not from true change in stimulus value. Dawes' (1971) report has special interest in this respect because it indicates that people with opposite views are perceived as more extreme than in fact they are. In addition, some evidence suggests that true stimulus contrast may be obtained under certain circumstances. Even if that is true, however, it does not justify the use of response measures that are severely contaminated by artifacts.

Judgmental context. The scale value of a word will certainly depend on the dimension of judgment. Masculinity is more desirable in men than women, for instance. This case is like that of words that have more than one principal meaning, and illustrates the role of the judgmental context in the valuation process. Similarly, the scale value of *lighthearted* would be different in judgments of likableness than of dependability.

Change of Weight

Discounting refers to decreased weighting owing to interaction among the informational stimuli. If a new piece of information is inconsistent with the old, the inconsistency can be reduced by assigning it less weight or importance. Direct evidence for inconsistency discounting in the personality-impression task is given by Anderson and Jacobson (1965) and Schümer and Cohen (1968). An important study using more realistic stimuli that bears on discounting processes has been made by Bugental, Kaswan, and Love (1970). Outlier discounting has also been studied (Anderson, 1968d). Moreover, the simplest form of redundancy interaction (e.g., Brewer, 1968; Dustin & Baldwin, 1966; Schmidt, 1969) would also correspond to decreases in weight. In contrast to the change of meaning hypothesis, then, the change of weight hypothesis seems to be on firm ground.

Stimulus interaction might possibly increase weight parameters. No evidence seems to exist, though increased weighting might occur when two stimuli form some natural unit. Chalmers (1969) has argued for both incremental and decremental weighting in personality impression formation by analogy with facilitation and interference in verbal learning. (It should be noted that Chalmers used the term, change of meaning, to refer to changes in the weight parameter.)

Discounting has received relatively little study, and that mainly with indirect measures, though an attempt to extend discounting analysis has been made by Schümer and Cohen (1968). Direct subjective estimates of importance would be most desirable, and some very tentative evidence for the usefulness of importance ratings is given in Anderson and Alexander (1971). Validation of such importance ratings would be especially valuable for configural analysis, since it is evident that discounting must depend on the configural pattern of the stimuli.

CONCLUDING COMMENTS

A distinctive feature of integration theory is its basis in a functional theory of measurement. Scaling thus becomes an organic part of the substantive investigation. The scales are developed and used directly in the substantive problem, and their validity rests on the validation of the psychological law. In some sense, this must be true of any measurement theory, but typically the scaling problem in psychology has been considered separately, to be accomplished as a methodological preliminary. In functional measurement theory, stimulus and response scaling and the psychological law are cofunctional in their development.

Integration theory is especially concerned with situations that require putting together several pieces of information. Such situations are not unique to opinions and attitudes. Learning, perception, judgment, and decision making also involve information integration. There should be a unified theory that covers all these areas. The present formulation has shown some initial promise in each of these areas, and it may provide a basis for the development of a unified general theory.

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