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COGNITIVE THEORY OF EVERYDAY LIFE

From the book **"A FUNCTIONAL THEORY OF COGNITION"**.
Appended are (a) the first chapter and (b) the prefaces for each chapter.
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Norman H. Anderson

Chapter 1: COGNITIVE THEORY OF EVERYDAY LIFE

Everyday life is characterized by conscious purposiveness. From reaching for food to designing an experiment, our actions are directed at goals. This purposiveness reveals itself partly in our conscious awareness, partly in the organization of our thought and action. Everyday life is thus an obvious, seemingly ideal place to begin, filled with promise for development of cognitive theory.

This promise has been tantalizing in the original Greek sense of that term: Tantalos, a son of Zeus and a king, was condemned in the afterlife to stand, racked with hunger and thirst, amid fruit-laden boughs in water up to his chin---with the fruit and water receding at each attempt to eat and drink. Many present-day psychologists feel like Tantalos. Our awareness of our feelings, desires, and goals ought to have shown the way to deeper understanding. Our immediate experience ought to have lighted a path to scientific theory. Many writers have sought to develop psychological theory on the basis of conscious experience. But, as with Tantalos, the sought-for understanding has receded at each attempt to eat and drink.

This recalcitrance of everyday experience to scientific development caused the dissolution of the original school of introspection. The main successor, the behaviorist movement, reacted against introspection by exiling consciousness. The psychoanalytic movement, otherwise very different, moved the prime locus of mental life to an unconscious realm, generally inaccessible to conscious awareness. The modern cognitive movement has welcomed consciousness home from exile, but has been deaf to affect and emotion. Since affect and emotion are central in our daily experience, these cognitive theories cannot say much about everyday life.

The theme of this volume is that scientific theory can be constructed around the concepts of everyday life. Everyday concepts are thus the focus of study, with the expectation that they can be established as scientific concepts. A partial list of everyday concepts will illustrate the broad field for study:

Psychophysical sensations such as sweetness and loudness.
Perceptual judgments such as size, distance, and movement.
Physical concepts such as time and torque.
Decision concepts such as cost, benefit, and probability.
Physiological reactions such as thirst, fatigue, and pain.
Emotional reactions such as joy and fear.
Interpersonal reactions such as admiration and envy, love and hate.
Moral judgments such as fairness and blame.
Goal experiences such as failure and success.

Self-concepts such as pride and ability.
Ego defenses such as excuses and self-pity.
And many more.

A good beginning has been made in the theory of information integration (IIT). IIT provides a unified, general theory of everyday life. Its generality appears in the spectrum of chapter titles, from person cognition and cognitive development to decision theory and language processing. Its unity appears in the applicability of the same concepts and methods across all these domains.
Moreover, IIT has a solid empirical foundation. It is not another promissory note. It is not only a manifesto but a working reality. It opens onto a new horizon in psychological science.

INFORMATION INTEGRATION THEORY

Two characteristics are basic to IIT. First is the functional perspective, which focuses on purposiveness of thought and action. Second is cognitive algebra. These two are interlinked: Purposiveness imposes a value representation that makes cognitive algebra possible; cognitive algebra provides effective analysis of value and hence of purposiveness.
This chapter gives a conceptual overview of IIT. This first part begins with the unifying theme of purposiveness. Purposiveness leads to two fundamental problems, multiple determination and personal value, and thence to concepts summarized in the integration diagram of Figure 1.1, collectively called the problem of the three unobservables.
The second part of the chapter illustrates method and theory with an experimental study of cognitive algebra in person cognition. The third part amplifies the functional perspective with topical discussions of meaning invariance, nonconsciousness, motivation, functional memory, and knowledge systems. The chapter concludes with a discussion of strategy of theory construction.

AXIOM OF PURPOSIVENESS [1]

Purposiveness is the prime axiom of psychology. The purposiveness of behavior has two main implications for IIT. The first is a functional perspective: Thought and action are conceptualized in terms of their functions in goal-directed behavior. This functional perspective entails sometimes substantial changes from customary views. Everyday life requires a functional conception of memory, for example, which is very different from the traditional conception of reproductive memory. Again, nonconscious emotion, which is virtually defined into nonexistence in traditional emotion theories, is an integral part of functional cognition.
The second implication of purposiveness, derived from the first, provides a means for its analysis. This is a one-dimensional representation of cognition. Thought and action have a basic approach--avoidance character; they are directed toward or away from goals. This is clear with affective senses, such as taste, temperature, and sex. These senses embody approach--avoidance polarity, which has evolved for goal-relevant function.
In everyday life, also, approach--avoidance is a fundamental axis of thought and action. Sports are typically centered on winning and losing, and similar success--failure dimensions appear in work and achievement. Our reactions to other persons exhibit a basic like--dislike dimension. An overall dimension of satisfaction--dissatisfaction pervades married life. These approach--avoidance continua represent purposiveness in a dimensional form.
This one-dimensional representation is encapsulated in the concept of value. Values embody and represent goal-directed thought and action. Although a one-dimensional value representation omits much of importance, it captures something of first importance, namely, goal directedness. Approach and avoidance are represented by positive and negative values

associated with goals. With this one-dimensional representation, quantitative analysis of complex behavior becomes thinkable.
But values must be measured. Measurement is necessary to quantify goal directedness. Measurement is necessary to actualize the value representation.
Measurement of values has long been controversial in psychology, even for simple sensations such as sweetness and loudness. We have no sucrometer to place on your tongue to measure your sensation of sweetness, nor any audiometer to implant in your auditory cortex. Even more problematic is measurement of feelings of affection, blame, unfairness, and other everyday experiences. Without a solution to this problem of value measurement, the one-dimensional representation of goal directedness has limited usefulness.
By a blessing of Nature, the measurement problem has a solution. The key came with the discovery of cognitive algebra. Work on IIT has revealed algebraic rules in nearly every domain. The stimulus terms in these algebraic rules embody one-dimensional values; the response term embodies the one-dimensional character of goal directedness. Stimulus and response measurement are both possible with cognitive algebra.
Moreover, cognitive algebra can operate at the level of conscious phenomenology, yet still analyze nonconscious concepts. Cognitive algebra thus provides a key to unlock the promise of conscious purposiveness.

MULTIPLE DETERMINATION

Virtually all judgment and action depend on more than one determinant. This is obvious in our social behavior. When we discipline a child, our action depends not only on the transgression, but also on our attribution about the child's intent, our desire to punish or instruct, and so on. When we meet a woman, we are influenced by her facial appearance and makeup, smile and gesture, dress, qualities of voice and language, and content and style of conversation. Marriage satisfaction depends on personal appreciation and quality of sex from your spouse and also on finances and children. Small moral problems, such as admitting fault or lying to save face, are everyday examples of conflicting factors. Such multiple determination is basic throughout the social--personality domain.
Multiple determination is equally important in other domains. In psychophysics, the taste of our food and drink depends not only on several sensations of the tongue, but also on visual cues and odor. Purchase decisions depend on cost--benefit analysis, taking account of price, quality, appearance, and other attributes. Understanding language depends on syntactic and semantic elements and also on contextual variables. Opinions on any professional issue, from education of graduate students to promising and unpromising problems for research, involve multiple pros and cons.
Development of general cognitive theory rests squarely on capability for analysis of multiple determination. This problem has resisted attack. Many psychological experiments, it is true, manipulate two or more variables and obtain multivariable tables of data. Such data tables, however, are generally descriptive and situation-specific. Sometimes they represent important phenomena; sometimes they are useful in testing local hypotheses. However, they do not lead to general theory.
Indeed, the disheartening but common conclusion of an extensive research program is that ``it all depends." Each new variable requires qualification of previous generalizations. The pattern of results grows more complicated with each new study. The more that is learned, the farther away theoretical unification recedes.
Cognitive algebra provides a new approach to multiple determination. It focuses on integration, that is, the rules whereby the various determinants are integrated into a unitary response. This can provide a foundation for theory because the same integration rules can apply to varied sets of determinants. Cognitive algebra can thus provide an underlying order and unifying framework for the surface complications of the innumerable determinants of

thought and action. The effectiveness of this line of attack will be demonstrated in each later empirical chapter.
The development of cognitive algebra, however, involved a second basic problem. This is the problem of psychological measurement, considered next.

PSYCHOLOGICAL MEASUREMENT

The concept of value, as already emphasized, offers a fundamental simplification of purposiveness. But values are personal. The importance and promise you attach to your own research often differ from the opinions of reviewers and colleagues. A wife's feelings of affection for her husband differ in many ways from his for her. Values differ across cultures; across social groups within each culture; and across individuals within each social group.
This basic fact of individual differences has been a quagmire for psychological science. How can general truths be established when individuals may differ sharply in the values that govern their thought and action? And how can individuals be understood without capability for measuring their personal values?
Both questions can be answered by cognitive algebra. Individuals may exhibit similar rules of multiple determination even though they differ in the personal values operative in these rules (see Figure 1.2). Some of these rules have algebraic form---this cognitive algebra provides a grounded theory of psychological measurement, with the needed capability for measuring personal values. The concepts and methods of this approach are outlined next.

INTEGRATION DIAGRAM

A conceptual overview of IIT appears in the simplified integration diagram of Figure 1.1. The organism is considered to reside in a multivariable field of observable stimuli, denoted by S_1, S_2, . . . , at the left of the diagram. These multiple stimuli are determinants of the observable response, R, at the right of the diagram. Between the observable stimuli and the observable response intervene three processing operators: valuation, integration, and action, denoted by bV, bI, and bA, respectively.
Also represented in the integration diagram is the operative goal, which controls all three processing operations. The purposiveness of thought and action is thus explicitly incorporated in the integration diagram. All three operators, accordingly, embody the construction principle discussed later.

Figure 1.1 here. Not available in this HTML version

Information integration diagram. Chain of three operators, bV -- bI -- bA, leads from observable stimulus field, S_i, to observable response, R. Valuation operator, bV, transforms observable stimuli, S_i, into subjective representations, psi_i. Integration operator, bI, transforms subjective stimulus field, psi_i, into implicit response, rho. Action operator, bA, transforms implicit response, rho, into observable response, R. (After N. H. Anderson, Foundations of Information Integration Theory. Academic Press, 1981.)
The valuation operator, bV, extracts information from stimuli. In the integration diagram, it refers to processing chains that lead from the observable stimuli, S_i, to their psychological representations, denoted by psi_i. Valuation may be as simple as tasting the sweetness of a drink or as difficult as interpreting the complaints of your spouse.
The goal has major influences in valuation. This goal influence holds even in early sensory links in the processing chain, in which motivational and attentional factors can influence the effective stimulus field. Goal influence increases in later links, as motivation and memory increase in importance. This is as it should be, for values are not in the stimuli, but are constructed by the organism.
Valuation may thus seem too fluid to pin down. An effective grip is possible, fortunately, by virtue of the unitization principle and bV -- bI independence.

The integration operator, bI, combines the several discrete psychological stimuli, psi_i, into a unitary response, denoted by rho. Integration thus represents multiple determination---the focus of IIT.
Multiple determination can be difficult to analyze. When even two factors are at work, each pushing in different directions, their combined effect is not generally predictable without quantitative theory. It is indeed a blessing of Nature, therefore, that some integration operators have simple algebraic forms. And this, as will be seen, carries the associated blessing of a foundation for theory of psychological measurement.
The action operator, bA, transforms the implicit response, rho, into the observable response, R. This rho -> R distinction is clearest with simple sensations: rho could be your private feeling of the loudness of a sound, for example, and R could be your rating of loudness on a 1--20 scale. As a more complex example, rho could be a feeling of irritation with your spouse, and R could be a verbal retort, facial grimace, or sullen silence.
The three operators are portrayed as independent and successive in the diagram. bV -- bI independence is a fundamental empirical finding, discussed in a later section. A more general diagram is necessary for many situation, but this simple version sets out the basic problem of the three unobservables.[2]

THE THREE UNOBSERVABLES

The most important entities in the integration diagram are unobservable. The integration operator is clearly unobservable, generally beyond the reach of introspection. The physical stimuli, S_i, are observable, but the corresponding psychological stimuli, psi_i, are inside the body, often nonconscious. The implicit response, rho, may be conscious, but it also is inside the body; the observable R may be severely biased as a measure of rho (see, e.g., Figure 3.1). These three unobservables are the focus of IIT.
The problem of the three unobservables seems formidable. To illustrate, suppose you are told that some person is level-headed and humorless, and asked to rate that person on a 1--20 scale of likableness. In a simple theoretical model, you would have to evaluate each given trait to determine its separate likableness value, then integrate these separate values to arrive at an overall judgment of likableness. Almost the simplest integration rule is addition. In words: Liking = Level-headed + Humorless.
More formally, in the notation of the integration diagram:
$rho_{Liking} = psi_{Level\text{-}headed} + psi_{Humorless}$.
This addition rule may well be false, of course, but the problem is to test it. This might seem straightforward: Measure the three terms, rho_{Liking}, $psi_{Level\text{-}headed}$, and $psi_{Humorless}$, and see if they add up.
Some form of this direct approach has been tried by various workers, but the test has generally failed. The three terms did not add up. Unfortunately, this outcome is ambiguous. The addition rule might still be true; the failure might result merely from a faulty measure of the response.
For what we measure is R, the observable rating, whereas the addition rule applies to the unobservable rho. A valid test requires that R be a veridical measure of rho. You may believe that your rating is a veridical measure of your feeling, but we cannot take your word for this. More definite evidence is needed. At the same time, veridical measures of the unobservable stimulus values, $psi_{Level\text{-}headed}$ and $psi_{Humorless}$, would also be needed.
This measurement problem is fundamental. Unless it can be solved, even the simple addition rule---wrong or right---will remain generally untestable. And if this simple rule cannot be tested, neither proved nor disproved, little hope appears for studying multiple determination of more complex form.
One reaction is that of behaviorism: Stick to the observables. Only unresolvable argument can come from trying to develop theories based on unobservable quantities. This behavioristic

reaction has much to be said for it, but it foregoes all hope of developing a theory of everyday experience.
A second reaction is to try to divide and conquer. The integration problem can be avoided by using only a single stimulus. With no integration, psi and rho become equivalent. This effectively reduces the three unobservables to one, which would seem easier to handle. This reaction is embodied in classical psychophysics, which sought to measure simple sensations such as sweetness and loudness. Avoiding the integration problem seemed altogether sensible, but it turned out to be self-defeating (Chapter 9).
Fortunately, there is a way to solve the problem of the three unobservables. In fact, it turns out to be rather simple. This was the foundation for cognitive algebra, as indicated next.

COGNITIVE ALGEBRA AND FUNCTIONAL MEASUREMENT

It is striking how simply the problem of the three unobservables can be solved. In the foregoing task of person cognition, manipulate the trait adjectives in a factorial design, plot the likableness judgments as a factorial graph, and inspect the pattern in this graph. A little overstated,

A pattern of parallelism solves the problem of the three unobservables.

Parallelism supports the hypothesized addition rule. At the same time, parallelism supports the working hypothesis that the observable R is a veridical measure of the unobservable rho. An additional analysis yields the psi values. All three unobservables thus have a solution. This functional measurement methodology is illustrated in the subsequent discussion of Figure 1.2.
It may seem surprising that so simple a methodology was not exploited much earlier. Conjectures about algebraic rules abound in psychology. Aristotle presented a ratio rule for fairness that is psychologically superior to a popular modern model (Chapter 7). Summation rules for warmth, loudness, and other sensations have often been suggested in psychophysics. In judgment--decision, degree of preference between two objects should obey a difference rule; expectancy for an outcome should multiply the value of the outcome. But virtually all these conjectures remained hopeful verbalisms, lacking mathematical backbone and psychological substance.
Several causes held back the discovery of cognitive algebra. First, the traditional approach to psychological measurement had to be inverted. Traditionally, measurement has been seen as a methodological preliminary to substantive inquiry, as with Thurstone's method of pair comparison scaling (Chapter 3). In the functional approach, in contrast, measurement is carried on as part of substantive study of the integration rule. Functional measurement is thus an organic component of empirical investigation.
A second obstacle to cognitive algebra concerned the rating response, which has been a mainstay of the experimental studies. The simplicity of parallelism analysis depends on the observable response being a veridical measure of the unobservable feeling. The rating method, however, has been generally condemned in other approaches to psychological measurement (Chapter 3). To obtain a veridical rating method requires certain experimental precautions, which, although not difficult in themselves, took time to establish. One contribution of IIT has been to put the rating method on a solid measurement-theoretical foundation, usable even with little children (Chapters 6 and 8).
A third obstacle to cognitive algebra was that many expected rules turned out to be incorrect, especially addition rules. Many tasks in which addition rules seemed indicated instead turned out to obey averaging rules. This markedly complicated the theoretical analysis, a matter discussed under Parallelism and Nonparallelism in Chapter 2.
A fourth obstacle was ways of thinking that have evolved to produce useful results while bypassing the fundamental problem of multiple determination. These ways of thinking came

to define the nature of the field, but they were inherently inadequate for unified, general theory. Instead, they are a major cause of the fragmentation of the field.
Cognitive algebra represents a new way of thinking. This provides a unifying theme that runs through virtually all psychology.

COGNITIVE ALGEBRA IN PERSON COGNITION

Person cognition is central in everyday life. Interpersonal interactions dominate family life: wife--husband, child--parent, siblings, relatives, and family friends. In most work situations, also, interpersonal relations have substantial roles, usually routine, occasionally crucial. Political and social knowledge systems often revolve around person cognition, as in U. S. history and in current civic issues. Abstract issues may take on new life when personified. This centrality of person cognition is underscored in drama and the novel.

EXPERIMENTAL ANALYSIS

Personality Adjective Task

In this experimental task, subjects received a short list of adjectives that described a hypothetical person and judged this person on likableness. This task has ecological validity. Our jugments of persons are often influenced by what others say about them. Letters of reference, for example, typically consist of strings of adjectives cast into sentence form. This task also has cognitive validity; it taps into cognitive processes continually ingrained in everyday life. In other ways, also, this task is ideal for experimental analysis (see Chapter 4).
The adjective lists were constructed from the Row mu Column factorial design illustrated for Subject F. F. in the left panel of Figure 1.2. Each of the nine data points represents F. F.'s judgment about likableness of one person, described by the two adjectives listed for the corresponding row and column (see also figure legend). Each subject judged a complete set of person descriptions on each of five successive days; this allowed separate analysis for each individual subject.
Theoretical Hypotheses. What should the results look like? A perennially popular hypothesis is that the adjectives interact with one another to form a unified conception of a person. Each adjective has various shades of meaning. Thus, bold may range from courageous to foolhardy; unsophisticated may range from gullible to unspoiled. The subject selects shades of meaning so that the adjectives in each description fit best together, thereby forming a person gestalt. This is one form of consistency principle, which asserts that subjects seek to maximize consistency in their perceptions of entities (Chapter 4).
This interaction hypothesis is called the meaning change hypothesis because it asserts that the effective meaning of each adjective will change, depending on which other adjectives it is combined with. Introspection endows this meaning change hypothesis with compelling face plausibility.
An alternative hypothesis is that the adjectives simply add without any interaction. This is a strong hypothesis; it assumes not only meaning invariance, but also specifies the exact form of the integration rule.

Figure 1.2 here. Not available in this HTML version

Parallelism pattern supports adding-type rule in person cognition. Subjects judged likableness of hypothetical persons described by two trait adjectives listed in the Row mu Column design: row adjectives of level-headed, unsophisticated, and ungrateful; column adjectives of good-natured, bold, and humorless. Each of these 3 mu 3 = 9 person descriptions corresponds to one data point. (Data averaged over third trait for simplicity; see Figure 1.4 of Anderson, 1982). (After N. H. Anderson, 1962, Application of an additive model to impression formation, Science, 138, 817-818. Copyright 1962 by American Association for Advancement of Science. Adapted with permission.)

This addition hypothesis makes a strong prediction: The curves in both factorial graphs of Figure 1.2 should be parallel. The meaning change hypothesis, in contrast, predicts nonparallelism. Nonparallelism is not a strong prediction, of course, because its locus is not specified. This would depend on semantic and pragmatic relations among the adjectives in each description. The rationale for these two predictions will be given under the Parallelism Theorem of Chapter 2. Here it need only be noted that the addition hypothesis makes a much stronger prediction than the meaning change hypothesis.

A strong test between the two hypotheses is thus provided by this experiment. Visual inspection will show whether the data are parallel or nonparallel. More interesting, perhaps, is the potential for analysis of interaction and meaning change. The locus of any nonparallelism should reflect which adjectives interacted and the nature of their interaction.

RESULTS: THE THREE UNOBSERVABLES

The results supported meaning invariance and the addition hypothesis. This follows from the near-parallelism observable in Figure 1.2, both for Subject F. F. in the left panel and for Subject R. H. in the right panel. This parallelism pattern solves the problem of the three unobservables. The implications of parallelism are discussed in the following three subsections, one for each unobservable.

Integration

Parallelism points to an adding-type rule. It is as though the subject assigns values to each adjective and adds them to determine the likableness of the person. Ten other subjects served in this experiment, with five additional sets of adjectives for stimulus generality. Similar parallelism was observed in all but three of the subjects. Only one of these, however, appeared to present any serious difficulty for the simple integration rule.

One qualification needs notice. The actual integration rule turns out to be averaging, not adding. Both can account for the parallelism observed here. The adding rule, however, fails in critical tests shown in Figures 2.4 and 4.4.

The disagreement of this result with introspection is notable. To phenomenology and introspection, the adjectives seem in dynamic interaction, each taking on different meanings depending on which other adjectives it is combined with. To phenomenology, person cognition appears to involve interactive organizing processes, in which the final outcome is a gestalt, not any simple sum of the separate adjectives.

But phenomenology was wrong. Functional measurement revealed a very different picture of person cognition. Valuation and integration both involve organizing processes, but their nature is very different from the claims of introspection. A theory of everyday cognition must thus be able to operate at a deeper level than phenomenology. This application of functional measurement showed that this must be done---and how it can be done.

Valuation

The second unobservable concerns the subjective values of the personality adjectives. Inspection of Figure 1.2 shows different values for the two subjects. For F. F., the equidistant vertical spacing of the three curves means that unsophisticated lies halfway between ungrateful and level-headed in likableness value. For R. H., however, unsophisticated is much closer to level-headed than to ungrateful. The values of the two subjects are thus essentially different. This value difference illustrates how parallelism analysis takes cognizance of the personal values of each individual subject.

Allowance for individual values is an obvious necessity for general theory of person cognition. We cannot predict F. F.'s judgments using R. H.'s values; these values are visibly different in Figure 1.2. Neither can we predict F. F.'s judgments if we have biased

measurement of F. F.'s values. By providing valid measures of individual values, the theory of functional measurement serves an essential function in development of general theory.

Action

The last unobservable is the internal feeling of likableness. Our problem is that the observed response may not be a veridical measure of the internal feeling. This is the R - rho distinction, discussed in relation to Figure 1.1. The observed parallelism, however, could hardly happen by accident. Hence it is encouraging support for response veridicality, in accord with the parallelism theorem of Chapter 2.

This issue is more important than might appear. Parallelism depends squarely on response veridicality. An adding-type rule will not yield parallelism unless the response is veridical. And in fact, there was ample reason to distrust the rating method (see discussion of Figure 3.1). With some simple experimental procedures, however, the rating method can provide veridical scales in many diverse tasks. This matter is discussed in Chapter 3, which also summarizes the interlocking network of evidence that supports the rating method. The veridicality of the rating methodology developed in IIT is an essential and integral component of cognitive algebra.

IMPLICATIONS

Developing a cognitive theory of everyday life involves a number of problems that are pointed up by the outcome of the foregoing experiment. Some of these are discussed in the following subsections.

Meaning Invariance

A recurrent claim in psychology has been that stimuli change their meaning in context. In the personality adjective task, for example, the quality of level-headed would be different in a bold person than in a humorless person. This meaning change hypothesis has been strongly advocated in this task, and indeed as a general characteristic of cognitive integration. Parallelism is strong evidence against meaning change. If adjectives did change meaning, taking on different values in different person descriptions, then parallelism would generally fail. The observed parallelism implies that value, and hence meaning, is the same in all descriptions. Within this task, therefore, each adjective has invariant meaning.

Phenomenologically, meaning change seems beyond doubt. Subjects and experimenters alike swear to it. But this phenomenological truth is a cognitive illusion. The methods of IIT can penetrate below phenomenology to reach a truer understanding of the nature of conscious experience. The present finding of meaning invariance has been extensively supported in other areas, most notably in psycholinguistics (Chapter 12).

Nomothetic--Idiographic Unity. The nomothetic approach seeks general laws that hold across individuals; the idiographic approach recognizes the uniqueness of each individual and seeks meaningfulness at an individual level. The nomothetic approach has been predominant in experimental analysis; its practitioners tend to consider it the only proper method of science. The idiographic approach has been predominant in personality psychology; its advocates tend to consider it the only meaningful psychological way. These two approaches generally have been in sharp disagreement.

IIT combines the nomothetic and idiographic approaches into a working unity. The valuation operation allows for individual differences, including the many heredity and environmental factors that make one individual different from another. Moreover, the valuation operation also allows variable motivation within the same individual over time.

The integration operation, in contrast, has some uniformity over individuals. The averaging rule, in particular, has proved ubiquitous. The idiographic nature of value is thus unified with

the nomothetic generality of cognitive algebra. Indeed, this nomothetic algebra provides the foundation for true measurement of idiographic value.

Psychological Measurement

Cognitive algebra demonstrates the necessity for a theory of psychological measurement through the act of providing such a theory. This has been seen in the contrast between the personal values of F. F. and R. H. in Figure 1.2. Parallelism analysis reveals this value difference by actually measuring the personal values. Without this measurement capability, the integration rule could not have been established.

No other theory has solved this measurement problem. Individual differences hardly have been denied, but cognitive psychology has massively ignored them. Nomothetic progress is possible by selecting amenable problems, as with testing typical single process hypotheses or assessing generality of interesting phenomena. Without idiographic measurement capability, however, general nomothetic theory is not possible.

Some idiographic progress is similarly possible by selecting qualitative problems that do not require measurement analysis. The two main idiographic approaches, however, have made limited progress. One approach relies on verbal reports, which can be seriously misleading, as with the meaning change hypothesis, and at best are fundamentally insufficient (e.g., Chapter 6). The other approach rests on crude forms of measurement that are inadequate for general theory of person cognition, as in popular trait theories and in attempts at measurement in judgment--decision theory (Chapter 10).

Expert Judgment

Person cognition is ubiquitous, not only in family and social life, but also in professional settings. For counselors and clinical psychologists, diplomats and politicians, chair of the board and leader of the street gang, person cognition is part of their way of life. Many consider themselves expert judges of others, but assessing the accuracy of such judgments is notoriously difficult. The present experiment does not assess accuracy, but it does reveal a strong cognitive illusion in self-report about such judgments. The common belief of expert judges, that their thinking is too subtle, contingent, and configural to be reduced to any simple formula, thus comes under question.

Other workers in judgment--decision have made a stronger argument, claiming that expert judgment can be mimicked by a linear, additive model for integration of information, and hence is not configural. Their evidence, however, suffers fatal defects---shown by the fact that the additive rule is generally false (see Chapter 10). Functional measurement methodology has instead found extensive evidence for the averaging rule, including findings of opposite effects that eliminate additive rules (e.g., Figures 10.2 and 10.3).

Cognitive Theory of Everyday Life

The cognitive illusion noted in the discussion of meaning invariance implies that phenomenology cannot be adequately understood at its own level and in its own terms. A deeper foundation is required. Much previous work, of course, has shown that people may be unaware of the effects of certain stimuli on their thought and action. The present result goes farther, however, for it shows that awareness may be subject to strong self-error.

This error of phenomenology points up a two-fold advantage of IIT. The success of the algebraic rule demonstrated the cognitive illusion and continued on to explain it (Chapter 4). Of more general importance, the algebraic rule provided capability for assaying the claims of phenomenology at their true worth. Theory centered on everyday life thus becomes possible.

Unified Theory

This experiment was the harbinger of cognitive algebra. It has been supported and extended in subsequent work. It has led to concepts and methods that have provided a fundamentally new

approach to general cognitive theory. Difficult problems still had to be overcome, as discussed in Chapter 4, but they were overcome.
Previous approaches were inherently too narrow to provide a base for general theory. They could not measure personal value, nor could they solve the integration problem. Even the conceptual distinction between valuation and integration has been a frequent source of confusion.
IIT, in contrast, has solved the twin problems of valuation and integration. This solution is general: It applies not only in person cognition (Chapter 4), but also in attitude theory and attribution (Chapter 5) and social development (Chapter 6). This solution is unified: The same concepts and methods have been productive across all these areas. Further generality and unity appear in later chapters on other areas, including judgment--decision theory and psycholinguistics. Although person cognition initially appeared unpromising as a field for cognitive algebra, it has turned out to be exceptionally fruitful.

FUNCTIONAL PERSPECTIVE

Purposiveness entails a functional perspective, in which thought and action are viewed in relation to their functions in the organism's goal-oriented behavior. Functional perspectives are not new; they typify everyday experience. More formal attempts at functional theory have often appeared in psychology, but their attractiveness has not been matched by effectiveness. Cognitive algebra, through its capabilities for analysis of values and goal-directedness, has contributed to effective functional analysis. A variety of implications are discussed in the following sections.
Meaning invariance is an important implication of cognitive algebra, first demonstrated in the experiment of Figure 1.2. To introspection, it seems overwhelmingly clear that the adjectives in a person description influence one another's meanings. Experimental analysis, however, demonstrated that the judgment obeyed an averaging rule---with invariant meanings of the adjectives.
Meaning invariance provides a novel opening for cognitive analysis. Measurement of values becomes potentially possible; their constancy means they can be pinned down. This potential can be actualized through cognitive algebra. Operating together, therefore, valuation--integration operations embody an idiographic--nomothetic harmony.
Meaning invariance is a general implication of cognitive algebra. Meaning invariance reappears in each domain covered in later empirical chapters, from moral development to language perception. In each domain, it reveals something about the nature of cognition and provides a base for further analysis.

bV -- bI INDEPENDENCE

The independence of valuation and integration is a corollary implication of cognitive algebra. Valuation itself is sensitive to the dimension of judgment. The same adjective, happy-go-lucky, for example, may have quite different values depending on whether the goal is to judge likableness, say, or reliability of the person. Given this goal, however, the adjectives are insensitive to one another. They do not ordinarily interact. It follows that valuation and integration are independent operators, as represented in the integration diagram.
bV -- bI independence is a significant finding about information processing. Information processing theories often run into trouble because the hypothesized processing stages appear to interact. At best, this makes interpretation difficult; at worst, it vitiates the presumed reality of the stages. Although bV -- bI interaction can occur, as when some informers are sharply inconsistent, for example, a normal mode is independence. It follows that bV and bI are distinct operators, representing distinct cognitive processes.
bV -- bI independence infirms some current views of information processing. Some theories of semantic memory, for example, represent meaning as a set of features. Integration, they

would argue, is accomplished by conjunction of the sets of features activated by the separate adjectives. This view implies that valuation and integration would be essentially similar. Hence this view cannot be generally correct.
bV -- bI independence has functional utility. Meaning invariance requires less processing than would meaning interaction. This is not mere insensitivity; the meanings are very sensitive to the goal through the valuation operation. Integration is analogously sensitive to the situation because the integrated output embodies multiple informers operative in the situation. Taken together, therefore, valuation and integration constitute an efficient and adaptive system.
bV -- bI independence provides a key to cognitive analysis, for it represents a factoring of the two operations. This makes functional measurement possible. Because the integration operator is factorable from valuation operator, it can be used as the base and frame for measurement---measurement functional in its dependence on task and goal.

CONSCIOUS AND NONCONSCIOUS

The immediacy of experience gives the impression that everyday life is lived essentially at a conscious level. Our everyday experience seems understandable in its own terms of purposes and feelings, an impression powerfully reinforced by human proclivities for verbal rationalization.
Much the same view underlies most phenomenological approaches. Current theories of action, in particular, typically rest on the foundation assumption that a theory of everyday experience can be developed within its own framework and in its own terms. Conscious experience thus constitutes what is to be explained---together with the means for explaining it.
Such phenomenological approaches exemplify the Tantalos metaphor with which this chapter began. Immediate experience continually promises a clear explanatory framework for thought and action. The idea that some way can yet be found to exploit this promise becomes an overwhelming temptation. Memory of the last failure dies away; hope kindles anew.
But nonconscious explanatory concepts are essential. Everyday experience is not comprehensible solely at its own level. A theory of everyday life must possess capability for analysis of nonconscious concepts. Nonconscious sensation, nonconscious affect, and nonconscious emotion must be accommodated within any general theory of everyday experience.
Nonconscious processes are well-known, of course, especially in perception. In the psychophysical study of the size--weight illusion of Figure 9.2, for example, the heaviness psi value for the cue of size was beyond the grasp of consciousness. Such nonconscious processes do not, however, preclude self-contained theory operating at the level of immediate experience.
Meaning invariance, in contrast, does indicate an essential need for nonconscious concepts. The strong phenomenological belief in meaning change was a cognitive illusion; consciousness was in self-error. This cognitive illusion is not a matter of empirical fact, however, as is the size--weight illusion, but a matter of theory. To demonstrate this illusion required development of a theory that could analyze nonconscious determinants of conscious experience.
Conscious experience is a priceless source of information. People can tell us invaluable truths about their mental states. In cognitive theory of everyday life, most concepts, from loudness to blame, derive from conscious experience. Furthermore, veridical quantitative self-reports of these experiences can be obtained with functional measurement methodology.
At the same time, conscious report is sometimes obstinately wrong, as with the illusion of meaning change. Functional measurement makes it possible to analyze nonconscious determinants of conscious experience. In this way, it offers a validational criterion for conscious report. It provides a unique, bilevel analysis of conscious and nonconscious, a necessity for cognitive theory of everyday life.

MOTIVATION, AFFECT, AND EMOTION

Motivations, in a functional view, may be considered biosocial knowledge systems. Biologically, motivations are survival systems; they represent biological knowledge developed in the course of evolution. In human societies, such biological bases are amplified and transformed. Food preferences and sexual behavior, for example, are heavily overlaid by social learning. Other human motivations, related to achievement and morality, for example, are far removed from biological drives, embodying knowledge developed through social evolution and assimilated through social learning.

All motivations, however, have a similar function: They place values, positive or negative, on aspects of the environment. This one-dimensional, goal-oriented value representation is a vital simplification and opening for analysis.

A single goal, of course, typically involves multiple motivations, as with approach--avoidance conflict. Understanding motivation thus involves problems of multiple determination and measurement of coactive values.

Integration analysis provides a new approach to motivation. Under certain conditions, the two problems of multiple determination and value measurement can be solved. Values represent motivation in a functional mode, as organism--goal interaction, or as drive--incentive interaction in traditional learning theory. Value measurement furnishes a rigorous approach to the teleological problem of defining motivation in terms of its consequences. Moreover, diverse kinds of motivation, both biological and social, can be treated jointly in comparable terms.

Affect is information. Quality and intensity of affect guide action. Biological examples appear in sensory systems. Taste is affective information to guide ingestion; temperature senses provide affective information that helps to maintain the internal environment. Social affects include moral feelings of right and shame and virtues of pride and submission, which help stabilize society and maintain the individual within society. Play and sex involve more complex affective systems that have informational and adaptive functions.

In this informational view, affect is an organic part of cognition. This view is reinforced by two integration considerations, relating to operating memory and long-term memory, respectively. Affect in operating memory depends generally on integration of nonaffective, ``cognitive'' factors, such as expectancy or social context. What reaches consciousness is an integrated unity. Such cognitive--affective reactions may then be stored in long-term knowledge systems. Social affects, in particular, thus depend on knowledge systems that include affect integrated into cognition.

Mainstream cognitive psychology has largely passed over affect, considering it qualitatively different from cognition. This narrowness has begun to be recognized, but it has constricted the conceptual framework. Affect cannot be tacked on at the end; it must be incorporated from the beginning. Cognitive theory of everyday life must give affect a central role. Cognitive algebra does this in fields as far apart as morality, psychophysics, and memory (see Chapters 7, 9, and 11).

Emotion is motivation with affect. This informational view reverses the popular arousal theories which claim nonaffective, ``cognitive'' information is essential to label and define the phenomenal quality of emotional experience. Far from requiring information to specify its own quality, affective experience constitutes information that is utilized in goal-oriented thought and action. In its simplest form, this informational function is analogous to that of sensory experience and makes equal biological sense.

Discussions of emotion have often stressed their disorganizing effects, in anger and panic reactions, for example, as though these were wholly irrational. This partial truth neglects the biosocial heuristic. A number of writers have indeed argued that emotions have useful, organizing roles, and greater attention has lately been given to positive emotions. A similar

view is adopted here, but with a shift in focus. The most common focus has been taxonomic, seeking to define a set of basic emotions, especially in terms of biological need systems. The present focus is on multiple determination. Problems of motivation integration provide a new base for theory development.

The need for an integrationist base for emotion theory is underscored by the consideration that emotions cannot be analyzed solely in their own terms. Nonemotional determinants are integrated into emotional reactions. Phobic reactions, for example, may depend on nearness, expectancy, and even verbal labels, determinants that are themselves nonemotional. The same holds for hope and envy, two important emotions of everyday life. ``Emotion'' and ``cognition'' cannot be well separated. General theory must be able to treat both in a unified way.

BIOSOCIAL HEURISTIC

The nature of human thought and action depends jointly on their biological foundation and on their social development. The human biosocial inheritance includes an array of motivational systems, ranging from ingestion and affection to perceptual, intellectual, and moral, that is efficient and adaptable. This adaptability may be seen in the continuing evolution of society and especially in its continuous reconstruction from new-born organisms.

Society, like biology, is concerned with survival. It has done remarkably well, on the whole, considering the unpromising origins and small size of the human brain. One key to success, as various writers have noted, lies in general purpose processes that can determine rough-and-ready action in diverse situations. A small brain can thus do reasonably well with simple means in many situations, even though it may do poorly in a few. These considerations reflect the biosocial heuristic for understanding behavior (Anderson, 1991a).

Social stereotypes furnish an apt application of the biosocial heuristic. Social stereotypes, in the present view, are adaptive knowledge systems that facilitate functioning in varied social situations. Stereotypes have long had a bad name as irrational and pernicious, almost by definition, because they were studied in relation to ethnic prejudice. That stereotypes are often superficial and inaccurate is certainly true, but they also furnish social stability. Society could not exist if its members did not have capabilities for forming and using stereotypes. To treat them as irrational and pernicious stems from lack of appreciation of the biosocial heuristic (Chapter 5).

The concept of biases in judgment--decision theory makes the same point. The standard normative approach prescribes optimal behavior, relative to which actual judgment--decision generally falls short; these shortcomings are considered biases, faults, and flaws of the organism. Instead, they may be optimal relative to limited processing capacities of a small brain. The faults and flaws seem instead to be in normative theory, which obstructs the development of functional theory (Chapter 10).

Despite its generality, the biosocial heuristic can be effective. It brings out the cognitive significance of affect and emotion, already discussed. It agrees with a functional conception of memory, considered later. In these and other ways, it leads to better appreciation of functioning cognition.

UNITIZATION PRINCIPLE

Cognitive algebra can treat complex stimuli as unitary. Exact theory is thus possible at a molar level, independent of more molecular structure of processing. Unitization potentiates self-sufficient theory of everyday cognition.

In the attitude experiment of Figure 5.1, for example, the stimuli were biographical paragraphs about American presidents, who were judged on statesmanship. Valuation of each paragraph involved a chain of processing that began with a distribution of light energy on the retina and continued with identification of these retinal stimuli as words and sentences,

understanding the content of each sentence, evaluating its implications relative to the assigned goal, and integrating across the several sentences in each paragraph. The end result of this extended chain of processing was representable as a single number: the value of the paragraph. This value constituted a complete and exact summary of all the processing. This value is thus a molar unit. This principle of molar unitization holds generally, from intuitive physics (Chapter 8) to language processing (Chapter 12).

Unitization relates to bV -- bI independence. In an alternative view, interaction would occur continuously along the processing chain from stimulus to response. In this flux, units would not be well defined. Valuation and integration would not be factorable, perhaps not distinct. Cognitive algebra thus affirms the principle of molar unitization and goes further to define and measure molar units.

Moreover, bV -- bI independence and the unitization principle may still apply even when no simple algebraic rule holds. On this basis, theoretical analysis can proceed at intermediate levels of information processing without having to await explication of prior levels.

Unitization is a key to cognitive theory of everyday experience. The diverse concepts of everyday experience, from psychophysical sensation to social affect, are potential concepts of scientific theory. A self-sufficient theory of everyday cognition is potentially attainable. Cognitive algebra helps convert this potential into actuality.[3]

Unitization can also help analyze more molecular processing: It provides boundary conditions that such processing must obey. Any molecular theory of valuation processing must agree with the molar values determinable with functional measurement. Similarly, any molecular theory of integration must agree with the rules established in cognitive algebra. Such boundary conditions can provide a unique window into the mind.

CONSTRUCTION PRINCIPLE

That cognition is constructive is an explicit premise of IIT. The construction principle applies to each operator---valuation, integration, and action---in the integration diagram of Figure 1.1. The constructive nature of integration is self-evident: To combine multiple determinants into a unitary response is construction. The ubiquity of multiple determination is one sign of the importance of the construction principle.

The constructive nature of valuation is shown by its dependence on the goal as well as on the stimulus. Value is not a constant property of the stimulus, but a variable that depends on the operative goal. Treating value as a variable is necessary for handling motivational states, in particular. These are primary determinants of value, but they change with time and circumstance.

Many values, of course, also involve integration. Indeed, molar values generally result from chains of more molecular bV -- bI -> bV -- bI -> . . . operations. In such processing chains, the integrated output of one link constitutes an input value for the next link. Essentially the same point appeared in the preceding discussion of unitization.

The constructive nature of action appears most clearly in goal dynamics, as in constructing a plan to attain some goal. But even the rating response, beneath its simplicity, involves a rather sophisticated construction of correspondence between unobservable rho and observable R (Chapter 3).

The construction principle is also prominent in assemblage of operating memory, discussed in following sections. Overall, the construction principle goes hand in hand with the functional perspective. Purposive behavior is adaptive behavior. Adaptive behavior requires construction as the organism utilizes its limited capabilities to function in diverse situations.

FUNCTIONAL MEMORY

The functional perspective entails a corresponding conception of memory, that is, memory as it functions in everyday life. One function of memory lies in construction of values relative to

the operative goal. Another function lies in the development of knowledge systems that store experience for later use in goal-directed thought and action.
Traditionally, memory is reproductive---epitomized as recall. This reproductive conception of memory has seemed almost its definition. Associated with this has been the reliance on accuracy measures, whose great usefulness has reinforced the reproductive conceptualization. But reproductive memory is insufficient, often barely relevant to memory function in everyday life.
The need for something more than reproductive memory was brought home in an early experiment on person memory. In this study, a hypothetical person was described by a list of trait adjectives; the subject judged overall likableness of the person and also recalled the adjectives. These two tasks are quite different: Recall pertains to the separate adjectives, whereas the person judgment involves an integration of all the adjectives into a unitary response.
According to the verbal memory hypothesis, recall probabilities would measure importance in the person judgment. If the initial adjectives were more important, for example, a primacy effect would be expected both in recall and in person judgment. This assumption that thought and action are determined by what is recalled from the given stimulus materials has been one base for the traditional reproductive conception of memory.
The results, however, revealed the operation of a person memory distinct from the verbal memory. Relevant meaning about the person was extracted from each adjective informer as it was received, and this meaning was integrated into a cumulative, on-line memory of the person. Once processed, the adjective was no longer needed, and in fact was forgotten or stored in a different memory. This was the origin of the functional memory representation.
Traditional, reproductive memory theory says little about memory function in everyday thought and action; reproduction of given stimulus materials is not the normal function of memory. Everyday memory typically deals with entities such as persons, objects, and events. Entity memory generally depends on integration of meanings or implications of multiple informers. These meanings are not usually in the stimulus informers per se. Instead, they arise from valuation of those informers relative to operative goals. Traditional memory theory, having virtually no place for goal-directed valuation---or integration---has limited relevance to these primary memory functions.
Functional memory requires a new way of thinking. Its analysis requires new kinds of experimental tasks, tasks that embody the valuation and integration operations of everyday judgment--decision. This and other issues of functional memory are taken up in Chapter 11.

SCHEMAS

Algebraic integration rules are schemas. They exhibit the primary characteristic of schemas, namely, organization that may be applied to more or less complex stimulus fields. As schemas, they go deeper than the algebraic form to emphasize qualitative aspects of the mental model of the task and goal at hand. This qualitative aspect appears more explicitly in specific schemas: the behavior--motivation--ability schemas of Chapter 5, for example, the blame schema of Chapter 6, the expectancy--value schema of Chapter 10, and especially the time--speed--distance schemas of Chapter 8.
Algebraic integration schemas are a singular exception to the vagueness of current schema formulations. Schema concepts flourished in the 1970s as psychologists gave greater attention to questions of organization. Mostly, however, the term schema was presented as an explanation, whereas it was what needed to be explained. Although the concept of schema pointed to important problems, analytical capabilities were lacking. Most formulations remain stuck little ahead of where they started. IIT, in contrast, has established exact structure of schemas in several domains.

This point may be illustrated with the concept of default values for missing information. For example, attributing causal responsibility for some harmful action depends not only on the harmfulness of the action, but also on the intention of the actor and/or situational constraints. If these latter factors are unknown, some value may be imputed to them in making the causal attribution. Imputation processes are important because pertinent information is often missing in everyday judgment--decision.

The concept of default values claimed to handle this problem of missing information. Schemas were considered to have slots, corresponding to relevant variables, filled with default values to be used when needed information was missing. This idea of slot-and-default value became almost a defining property of schemas in some prominent formulations. Cognitive algebra furnishes an ideal proving ground for formulations based on slot-and-default value. The stimulus variables of any algebraic rule correspond to the slots; the default value is what should be used when information about some variable is not specified. This problem of missing information has been extensively studied in IIT.

The experimental data, however, disagree with the concept of slot-and-default value. People often do not impute any value to an unspecified variable. When they do, the value might be nonconstant, dependent on the situation. The concept of slot-and-default value cannot handle such results (e.g., Chapter 7).

In retrospect, it is clear that the slot-and-default value formulations were mainly armchair analogies to computer programs, without serious foundation in psychological science. Schema concepts need to be substantially more flexible to represent thought and action. Cognitive algebra has this flexibility.

ASSEMBLAGE

Thought and action typically require assemblage of diverse contents into an operating memory for the task at hand. Assemblage is explicit in the constructive nature of valuation and inherent in the concept of integration. These are only aspects of operating memory, however, which will generally include representations of goals, some mental model of the task, together with activated background knowledge that is utilized in thought and action. Operating memory thus consists of heterogeneous contents assembled and joined together in relation to operative goal directions---qualitative integration, in other words, to which the term assemblage may be appropriately applied.

The concept of assemblage unifies the construction principle and functional memory. The necessity for a concept of assemblage appears in the multiplicity of possible goals. Assemblage relates the mass of background knowledge to the active operating memory that represents momentary purposiveness. Assemblage goes beyond the reproductive conception of memory retrieval to the functional role of memory in constructive processes.[4]

KNOWLEDGE SYSTEMS

A concept of knowledge system, more general than schema, is also needed to represent organization in memory. Some properties of knowledge systems may be illustrated with four concepts taken from the social--personality domain: attitudes, roles, traits, and persons.

In attitude theory, IIT distinguishes attitude as a knowledge system from attitudinal responses, which are functional manifestations of that knowledge system in thought and action. In the study of attitudes toward U. S. presidents of Figure 5.1, for example, the knowledge system about any president will contain information from history courses and general reading, additional information given in the experiment, as well as affective-valuational information relating to ideals for presidents and social--political issues. This knowledge system is processed to help construct specific attitudinal responses, as with the judgment of statesmanship. Attitude as knowledge system thus differs qualitatively from attitudinal response.

Most attitude theories, in contrast, have defined attitude as a one-dimensional evaluative reaction. This is only an attitudinal response, in IIT, and indeed only one class thereof. Such attitudinal responses should not be confused with attitudes as knowledge systems, which may subserve many different attitudinal responses.

This view also clarifies the common finding of low correlations between attitudes and behavior, which has been perplexing to traditional theories. This perplexity reflects a too-narrow concept of attitude. To obtain high correlation would require the same one-dimensional measure of attitude to be a good predictor in many different situations. As a knowledge system, however, an attitude can function adaptively in many situations. Almost necessarily, therefore, any one-dimensional index of attitude will yield low correlation because behavior depends also on components of the knowledge system whose activation in operating memory reflects situational specifics.

Roles are knowledge systems organized for action. For many social roles, the main content consists of prescriptions for speech and behavior appropriate to particular situations. In the present functional view, role enactments on particular occasions obey the construction principle. As with attitudes, accordingly, a qualitative distinction is needed between roles as knowledge systems and particular role enactments subserved by that knowledge system.

It may seem odd to consider traits such as honesty, perseverance, and sociability as knowledge systems. A traditional conception, especially in trait theories of personality, treats traits as one-dimensional properties of the person much as a physical object may be specified by its mass, velocity, temperature, and so on. In the present functional view, in contrast, traits represent general organization of personal functioning.

A long-standing embarrassment of trait theories of personality is that traits have low correlations with behavior. This embarrassment stems from a too-narrow conception of trait, exactly like that just discussed for attitudes.

The trait of honesty, for example, is a functional system that helps guide behavior in diverse social situations. Reducing this system to a one-dimensional trait score can sometimes have practical usefulness. This score, however, should not be confused with the underlying knowledge system.

Traits as knowledge systems include situational information for social functioning. Honesty is not absolute; acceptable and even meritorious standards of dishonesty depend on the situation. Conflicts of honesty are not uncommon and need to be resolved by reference to strengths of particular obligations. It is such knowledge systems that constitute honesty and other personal traits.[5]

Knowledge systems reach a culmination in person cognition. Our memory representation of a particular person includes both generic and particular elements organized in ways that partially embody perceived regularities in that person's behavior. The behavior--motivation--ability schemas of Chapter 5 and other generic schemas may thus become particularized into the knowledge systems that constitute our memory of a person. Similar general--particular processes hold for trait, role, and attitude components of memory of individual persons.

Specific interactions with the person, imagined or actual, involve assemblage that takes account of the immediate goal and situation. This is an operating complex that includes not only contributions from specific person memory, but also from general person cognition, as well as from nonpersonal knowledge systems (e.g., Chapters 10 and 11).

From these four examples, the concept of knowledge system may seem too flexible and too complex to be useful. This flexible complexity, however, reflects cognitive reality. It is preferable to recognize this complexity in the conceptual framework than to obscure or deny it, as in traditional theories of attitudes and personality traits.

Knowledge systems and assemblage involve qualitative integration. Although qualitative integration represents a major incompleteness in IIT, cognitive algebra can make useful contributions. Reflected in the value representation of purposiveness, much qualitative

integration leads to quantitative response. In turn, these quantitative responses can furnish helpful clues and tracers for analysis of qualitative structure. Some qualitative, conceptual implications of cognitive algebra are itemized in the final section of this book, Beyond Cognitive Algebra.

STRATEGY OF THEORY CONSTRUCTION

Theory construction in information integration theory follows a strategy that may be described as inductive and molar. This inductive, molar strategy gives the theory a different character from the most popular alternatives, as noted in the following sections.

MOLAR THEORY AND MICRO THEORY

The functional perspective adopted in IIT leads naturally to a molar approach. Goals, as represented in phenomenology, are themselves molar. It is desirable to represent these concepts at their own level---without necessary concern for the complex chains of processing that underlie them.

Cognitive algebra has this molar capability, as noted in the earlier discussions of molar unitization and bV -- bI independence. Moreover, cognitive algebra provides validational criteria to establish itself. A self-sufficient theoretical framework for phenomenology thus becomes available.

A parallel may be seen in thermodynamics. Thermodynamics is a self-sufficient theory, independent of an explanatory base in statistical mechanics. Of course, cognitive algebra does not begin to compare with the grandeur of thermodynamics, but it does claim to be self-sufficient at a molar level. This claim rests on an extensive base of experimental analysis.

Molecular theories, or micro theories, seek some primitive level of elements, typically hypothetical, as a foundation for theory. Micro strategy appears in the classical associationist views and remains overwhelmingly popular today. Micro strategy has done well in physics and even in physiology. In social science, however, its reductionist promise remains unfulfilled.

Given the validity of the averaging rule, for example, it is not difficult to hypothesize micro entities that exhibit an averaging process, and thereby purport to ``explain" averaging. Several such micro hypotheses are noted in Chapter 2. Such exercises are specious as explanations, however, until they have been expanded into interlocking theory. Until then, the effective direction of explanation is just the reverse: from known to unknown, that is, from macro to micro. Overtly or covertly, it is the macro results that determine the micro assumptions.

Only by finessing the micro level was it possible to establish cognitive algebra. Now these algebraic rules provide a base and frame for self-sufficient theory at the functional level of everyday experience.

IIT does not disregard micro approaches. It places high importance on more molecular processes in mental models and assemblage. It argues for a functional conception of memory distributed through diverse knowledge systems. In conjunction therewith, it assumes parallel processing as a means of similarity assessment in the valuation operation.

Moreover, cognitive algebra can help micro theories by providing boundary conditions for their development. One boundary condition is the algebraic structure of the averaging model, just discussed. Meaning invariance, similarly, is a boundary condition of ramified importance.

GENERAL THEORY AND MINI--THEORY

Theory construction in IIT contrasts in a different way with another alternative, which may be called mini-theory strategy. Although mini-theories are often molar, they are not general but specific, focused on particular issues. The attractiveness and undoubted usefulness of mini-theory strategy needs to be balanced against serious shortcomings.

A common complaint about mini-theories is lack of development; their expansion is often just complication. It is often easy to postulate concepts and processes that ostensibly account for most known results on particular issues. Typically, however, further tests run into difficulties that require additional assumption or qualification. Such complications multiply, with concomitant decrease in theoretical scope and power.

A major reservation about mini-theories is their responsibility for the compartmentalization and fragmentation that characterize contemporary psychology. Except for occasional fads, each mini-theory typically has a mini-group of proponents, who have minimal interaction with other mini-theories.

This fragmentation is pervasive. Curiously, it is more or less accepted as the normal state of affairs. This should not be. A shift in strategy of theory construction is needed. This requires substantial change in the conceptual framework that currently guides research.

A major reason for fragmentation and limited progress may be seen in the character of most mini-theories. Without realizing it, they have usually been concerned with determinants of values and with valuation processes in particular tasks. Mini-theories sometimes address integration, it is true, but for this they have generally been inadequate. Indeed, they typically become confused from confounding the concepts of valuation and integration, as in many cognitive consistency theories. Mini-theories of valuation are important, but order and law will continue elusive with standard strategy because of the innumerable determinants of value. Integration theory often seems strange, almost atheoretical, to workers accustomed to standard mini-theories. Concepts and processes of mini-theories usually seem psychologically real and pregnant, having concrete situational meaning. This phenomenal reality seems lacking in such trans-situational concepts as informer, value, and integration used in IIT.

A more general theory, however, can be at once simpler and more powerful than special theories. Examples include the analysis of schemas, previously mentioned, the cognitive consistency theories discussed in Chapter 4, developmental processes in knowledge of the external world (Chapter 8), grounded cognitive framework for judgment--decision (Chapter 10), and contextual interaction in psycholinguistics (Chapter 12). In all these cases, the concepts and methods of IIT were effective with simple analyses.

Mini-theories are important and essential. They are at their best when exploring new phenomena, an activity that underlies the vitality and fascination of current psychological research. They also have the great merit of seeking careful, detailed explication of particular tasks rather than vague generalities. What is needed is a shift in strategy, in which the mini-theory trees do not obscure the forest of general theory.

INDUCTIVE STRATEGY AND DEDUCTIVE STRATEGY

In the inductive mode of theory construction, generalizations are sought as emergents from experimental analysis. The deductive mode, in contrast, begins with postulates and seeks to test discriminative predictions therefrom. Both modes are important, and both appear in any scientific inquiry.

It makes a big difference, however, which mode is taken as primary. The inductive mode is primary in IIT, whereas the deductive mode is primary in most mini-theory and micro approaches. Many of the foregoing differences between IIT and these two approaches stem from this inductive--deductive orientation.

This difference may be illustrated with cognitive algebra, as with the averaging model at issue in the experiment of Figure 1.2. In a narrow sense, this parallelism test of the model might seem a fine example of the classical hypothetico-deductive strategy. In actuality, matters were considerably more complicated. Altogether, seven basic theoretical issues had to be resolved to put the averaging model on firm ground, as will be detailed in Chapter 4.

The analyses of Chapter 4 did involve essential deductive elements, but this should not obscure the primarily inductive nature of this investigation. The solidity of the theoretical structure depends on the network of results, especially as concerns the basic issue of response measurement, covered in Chapter 3. The empirical procedures developed for response measurement are thus an essential component of the theory. The question of where the averaging model holds, moreover, remains primarily a question of empirical generalization. Cognitive algebra rests on empirical demonstrations of algebraic rules common across diverse domains. Its validity resides in these experimental analyses, not in hypotheses or axioms, but distributed through the empirico--theoretical network. As said previously (Anderson, 1981a, pp. 82-83):

Many psychological theories claim to operate in the deductive mode. It is often considered to be the ideal, sometimes the only, truly scientific way of thinking. Workers in the deductive mode often have difficulty comprehending inductive theory; to them, it appears formless and uncertain. To workers in the inductive mode, however, the deductive mode appears simplistic, not to say specious, beyond the local level. Among other reasons, what passes for deductive theory in psychology is typically an awkward form of inductive theory.

For the plain fact is that deductive theories are rarely abandoned when their deductions fail. Instead, they are modified, first in their auxiliary simplifying assumptions, later in their basic conceptual assumptions. Deductive theories in psychology typically exhibit a short, initial period of deductive flourish, followed by slow, grudging assimilation of inductive change. Open acceptance of a more inductive approach as a basic research orientation would seem developmentally more truthful, not to say more efficient.

Inductive theory views science not as formalized knowledge, but as living inquiry. It recognizes and incorporates background thinking and experimental lore, including pesky problems of apparatus and organism, that are obscured or lost in deductive formalizations. And is is more open to nature, which continually reveals new riches to surprise and delight her students.

The prominence of hypothetico-deductive strategy stems in large part from its utility in physical science. In social science, however, hypothetico-deductive strategy has done poorly, as is illustrated with mini-theories. The lack of cumulative progress, noted by various writers, is a consequence of adopting a strategy that is inappropriate to the nature of the phenomena. The effectiveness of the inductive approach will be demonstrated by its applications across diverse fields of psychology, generally considered quite different and unrelated, in the later empirical chapters. This effectiveness depended substantially on cognitive algebra and functional measurement, which have transformed the axiom of purposiveness into a working principle. With these concepts and methods, the data often speak for themselves. This is more effective than the hypothesis testing typical of mini-theories and micro approaches. By seeking order at the level of integration, it was possible to avoid bogging down in the swamp of multiple determinants of valuation.

INTERNAL WORLD AND EXTERNAL WORLD

Psychology is unique in its concern with an inner world distinct from the external world studied in other sciences, such as physics and physiology. The existence of this inner world is self-evident in conscious experience, but it has resisted analysis.

IIT is founded on structure in the inner world. Internal structure provides the base and frame for theory construction. Most other theories, in contrast, place essential reliance on the external world. Some even deny meaningfulness or relevance to the internal world. This internal--external difference leads to qualitative differences in the nature of theory and direction of inquiry.

Reliance on the external world is certainly sensible. Attempts to exploit the internal world through introspection have repeatedly been disappointing, as noted in the Tantalos metaphor

at the beginning of this chapter. Moreover, the internal world has a biological function of survival in the external world, and so should mirror---and be mirrored in---its structure.
This is clear in visual perception. We take for granted that our visual world is a replica of the external world. Indeed, some theories, modern as well as ancient, consider visual perception to be direct apprehension of the external world. This approach failed, however, in measuring simple psychophysical sensations. Integration psychophysics, in contrast, was able to measure sensation in the internal world (Chapter 9).
Reliance on the external world appears everywhere in psychology. Memory, for example, has virtually been defined in terms of the external standard of accuracy of reproduction of given stimulus materials. This reliance on the external world, although extremely useful for certain purposes, has quite obscured the functional character of memory in thought and action (see Functional Memory above and in Chapter 11).
A different kind of reliance on the external world appears in the dominant normative orientation in judgment--decision theory. There thought and action are conceptualized in a framework of optimal behavior---defined by objective standards in the external world. This normative approach is contradicted by cognitive algebra, which differs qualitatively from normative algebra. The prime example is the averaging model, which yields a nonprobabilistic disproof of the sure-thing axiom, once considered a cornerstone for judgment--decision theory (Chapter 10). The decision averaging model, moreover, has proved superior to the analogous normative Bayesian decision model.
A similar case history appears in developmental analysis of intuitive physics. Here the external world sets a standard in the form of physical laws of simple algebraic form. These laws control reinforcement in the external world of daily experience, so it was an attractive assumption that children would learn them. This isomorphism assumption proved a false alley. Intuitive physics does obey algebraic rules, but these cognitive rules often differ from those of the external physical world (Chapter 8).
This argument of nonisomorphism is pertinent to learning theories, from operant to connectionist, that rely on external reinforcement. The ability of organisms to learn something about reinforcement structure in the external world has furnished valuable leverage for psychological analysis. This is not sufficient, however, as shown by the cited examples of nonisomorphic rules from cognitive algebra. And regardless of cognitive algebra, the insufficiency of traditional memory theory follows simply from recognition of memory function in everyday life.
A priori, reliance on internal structure seems unattractive. Formidable difficulties appeared in the problem of the three unobservables of Figure 1.1. In this diagram, internal structure has three aspects, one corresponding to each unobservable. Two are metric structures, for the stimulus variables and for the response; the third is qualitative structure of the integration function. A divide-and-conquer strategy naturally seems more sensible than trying to solve all three unobservables together. As it happened, divide-and-conquer did not solve even one unobservable. Instead, it misdirected the path of inquiry.
The potential of internal structure as a foundation for theory was illustrated in the parallelism theorem and its empirical application in Figure 1.2. Internal structure of additivity allows a simple solution to all three unobservables together. More important, as it turned out, this method of structural analysis also holds for the general averaging rule, despite the real difficulties in the theoretical development (see Parallelism and Nonparallelism in Chapter 2).
In the end, cognitive algebra was found to be a general characteristic of thought and action. This internal algebraic structure provided a base and frame for a general functional theory of cognition.

PHENOMENOLOGY

Cognitive algebra provides a base for self-sufficient theory of phenomenology of everyday life. Self-sufficient theory is not obviously attainable, for multiple levels or stages are usually operative. In the study of person cognition of Figure 1.2, for example, the valuation process for each single adjective represents an intricate chain that begins with sensory stimulation, leads on to identification of letter, word, and lexical meaning, to goal-directed similarity comparisons with distributed memory for constructing task-relevant values, to incorporation in an operating memory, and perhaps to further interaction in the integration process. This partial view of the chain indicates the terrible complexity of complete process analysis of valuation, let alone integration and action.

Within this flux of processing, cognitive algebra provides an Archimedean fulcrum of stability. No matter how intricate the chain of valuation, the net result is typically a single value, as discussed under unitization. The validity and usefulness of this unitization principle rest heavily on the twin findings of meaning invariance and bV -- bI independence in cognitive algebra.

The development of cognitive algebra has relied heavily on phenomenology. The terms or concepts of the algebraic rules studied so far have mostly been taken from everyday experience. The idea of algebraic rules of cognition has a similar origin in everyday thinking. In both respects, phenomenology provided a priceless beginning.[6]

Phenomenology is not by itself a sufficient base for theory. Nonconscious concepts are essential. Moreover, phenomenology can make stubborn errors, as in the meaning change controversy and in certain forms of ego defense.

Cognitive algebra can remedy both shortcomings of phenomenology. Algebraic structure constitutes a criterion to assay and refine ideas and concepts of everyday experience. Capitalizing on phenomenology in this manner seems more effective in many ways than seeking a primitive micro level of explanation. Moreover, cognitive algebra explicitly incorporates a functional perspective with its focus on the purposiveness of everyday thought and action.

UNIFIED THEORY

IIT aims to develop a unified, general theory that treats everyday experience in something like its own terms. The terrain for investigation is broad: Sensory--perceptual reactions that direct our movements in the world around us; biosocial motivations that guide our approach--avoidance; memory functions that incorporate learning from experience; judgment--decision capabilities utilized in our thought and action; and moral--social knowledge systems that operate in our interactions with other persons. Of special significance are the feelings, strivings, thoughts, skills, and actions that characterize that central entity, our self.

The potential for unification lies in purposiveness. To actualize this potential requires resolution of two fundamental problems: measurement and multiple determination. The concept of value, as noted in the introduction, provides a basic simplification for analysis of purposiveness. Values differ across persons, however, so general theory must provide capability for measurement of personal values. The companion problem of multiple determination arises because any one goal typically involves multiple values.

By a blessing of Nature, the two problems can be solved jointly with cognitive algebra. Cognitive algebra is general, applying across nearly all domains of psychology. It appears to be a biosocial universal. Cognitive algebra is unified, for the same concepts and methods apply in all these domains.

An integration approach involves a new way of thinking that is sometimes hard to comprehend from traditional perspectives. This new way of thinking is epitomized in the present approach to multiple determination and psychological measurement, discussed further

in Chapter 3. This way of thinking ramifies through all aspects of inquiry, from choice of experimental question, task, response measure, and design, from conceptions of memory, affect, and knowledge systems, to the structure of theory itself. Some aspects of this new way of thinking have been indicated in this chapter and will be amplified in later chapters. Indeed, each later chapter revolves around a clash between old and new ways of thinking.[7]
The contributions of this work are modest, but they are real. Beyond the establishment of exact algebraic laws of cognition, this approach also yields conceptual implications for qualitative cognition (see Beyond Cognitive Algebra at end of Chapter 13). This work, it seems fair to say, constitutes a good beginning on unified theory of everyday cognition.

NOTES

Two source books on the theory of information integration are the Foundations and Methods volumes (Anderson, 1981a, 1982). More recent developments by a number of workers are summarized in three Contributions volumes (Anderson, 1991b,c,d), respectively reviewed by Sjöberg (1994), Pratkanis (1994), and Bogartz (1994).

1.

Purposiveness deserves the status of an axiom since it has been considered self-evident even by most of those who disown it theoretically. Although the main lines of psychological science have shunned purposiveness, many writers have attempted to develop formulations based on goal concepts and functional perspectives. Among these are the neglected Darwinian purposive behaviorism of McDougall (e.g., 1928; see also Tolman, 1959) and a variety of functional perspectives stemming from James and Dewey, also based on Darwinian ideas. Comparison of IIT with these formulations is beyond the scope of this book; useful references are Boring (1950), Vygotsky (1978), McGuire (1983), Bandura (1986), Frese and Sabini (1985), and Pervin (1989).
All the concepts of this chapter have been considered by other writers. The construction principle, for example, was primary in the formulation of Helmholtz. The complex lineage of ideas in emotion theory is covered in the learned volume of Mandler (1984). To attempt to relate the manifold indebtedness of the present discussion to this and other previous work would require at least another volume. The present treatment aims to show how these concepts arise and function within IIT in a simple way, with no claim for originality in most of what is said.
The main claims for originality in IIT are two: Development of capabilities for solving the two basic problems of multiple determination and psychological measurement; and experimental application of these capabilities to develop an interlocking framework across many psychological domains. Functional measurement theory has thus made purposiveness a legitimate theoretical construct, properly deserving the status of an axiom.

2.

The integration diagram of Figure 1.1 is useful for setting out the problem of the three unobservables, but it represents only a simple case. Stimuli may be internal as well as external, and the valuation operation, here treated as a molar unit, may consist of a chain of valuation--integration operations. Valuation and integration will not always be independent, moreover, as with inconsistency and redundancy (see Chapter 11). In addition, action evolves temporally with feedback. Hence the stimulus field will change over time, reflecting interaction between action and valuation operations, as the organism approaches the goal.

3.

Unitization seems similar and related to categorization as a fundamental ability, but it has received relatively little directed analysis. One line of inquiry would consider cases in which

unitization does not occur. Examples appear in inconsistency reactions (Chapter 11) and in comparing hypotheses of input integration and equity integration (Chapter 7). More extreme examples are sometimes found with information overload, conflict, and emotional reactions, in which normal integration processes seem to fail. Another line of inquiry concerns unitization as a result of integration across different sense modalities, as in psychophysics and psycholinguistics.

4.

Experimental analysis of assemblage in operating memory seems promising in intuitive physics. In the study of Figure 8.1 of Chapter 8, for example, the children's judgments rested on a qualitative assemblage representing the physical structure of the task. This assemblage is more important, and more interesting, than the algebraic rule that it subserves (see also Assemblage Theory in Anderson & Wilkening, 1991, pp. 20-24).

5.

The trait, honesty, is used in tribute to Hartshorne and May (1928), who showed that honest--dishonest behavior of school children depended very much on situation and circumstance. Honesty could not be considered a general personality trait, therefore, an implication long neglected in personality theory. Instead, honesty, and by inference other personality traits, involved person--situation interaction and indeed constituted some kind of knowledge system. The research program of Hartshorne and May commands admiration and still stands out as a model for other workers (see Mischel, 1968).

6.

Some philosophers (e.g., Churchland, 1979; Stich, 1983) have argued that everyday concepts and beliefs, so-called folk psychology, are totally lacking in validity and have nothing to contribute to cognitive science. Some other foundation must be found.

Cognitive algebra leads to an opposite conclusion. It demonstrates the validity of some concepts and beliefs of folk psychology. Folk psychology can thus contribute to cognitive science, contributions not merely invaluable, but unique.

The working hypothesis of IIT has been that everyday cognition, or folk psychology, is an essential base for construction of cognitive theory. The conceptual terms in the algebraic schemas cited earlier, for example, were taken from everyday cognition. The empirical validation of these schemas demonstrates validity of phenomenology. In this way, phenomenology can be exploited and expanded for rigorous theory.

Of course, understanding folk psychology is not possible solely in its own terms. Folk psychology is sometimes obstinately incorrect, as shown by the persistence of the meaning change hypothesis. Also, folk psychology is essentially incomplete, as shown by the importance of nonconscious sensation and nonconscious emotion. But belaboring the limitations and shortcomings of everyday phenomenology does not demonstrate its uselessness. Physics also has been obstinately incorrect at times, as with the concept of ether. Cognitive algebra has an essential role in assaying and refining folk psychology.

A compendium of philosopher's views, pro and con, on folk psychology is given in Christensen and Turner (1993). The functional view of IIT agrees with the functional view in philosophy (Christensen & Turner, 1993, pp. xxii-xxiv) in considering folk psychology a basis for a rigorous science of mind without requiring reduction to a lower level. IIT does not, however, deny that such reduction is possible in principle. Moreover, IIT makes no appeal to ``theory of computation and formal logic.'' Instead, it lays a foundation with algebraic laws of mind, just as physics employs algebraic laws of matter.

7.

Multiple determination is widely recognized throughout psychology, of course, most prominently in the algebraic models conjectured throughout the judgment--decision domain. Similar conjectures appear in additive attitude theories (Chapter 5) and moral algebra (Chapter 7). Multiple determination is also conceptually integral to contextual effects in psychophysics (Chapter 9) and language processing (Chapter 12), to the concept of inconsistency in cognitive consistency theories (Chapter 4), to person--situation interactionism, and to intuitive physics (Chapter 8).

Effective analysis of multiple determination, however, has been lacking in all these areas because they lacked a grounded theory of psychological measurement. The need for measurement theory is well illustrated by the shortcomings of the makeshift measurement methods in judgment--decision theory and in the widespread reliance on magnitude estimation in psychophysics.

Functional measurement theory has provided a foundation for the study of multiple determination. This foundation is grounded in the empirical demonstrations of cognitive algebra presented in the later empirical chapters. Unique to this work is the averaging model, which entails an essentially new outlook on psychological measurement. Because of its emphasis on continuous response, moreover, functional measurement can also be useful with analysis of nonalgebraic integration and configurality.

Prefaces to A FUNCTIONAL THEORY OF COGNITION

Norman H. Anderson

Chapter 1 Preface: COGNITIVE THEORY OF EVERYDAY LIFE

The conscious purposiveness so prominent in our everyday life has been perennially attractive as a base for psychological science---and has proved perennially disappointing. Much cognition is nonconscious; what is accessible to consciousness has failed to provide a base for theory. Purposiveness itself has been much condemned, like teleological concepts in physics.

This book presents a functional theory of cognition, founded on the axiom of purposiveness and grounded in cognitive algebra. The functional nature of cognition manifests itself in an approach--avoidance axis of thought and action. This axis provides a one-dimensional representation of cognition in terms of value, positive and negative. Functional value pervades cognition and provides a unifying base for analysis.

Cognitive algebra gives a cutting edge to the axiom of purposiveness. Multiple determinants, and hence multiple values, typically operate in thought and action. These multiple values are integrated by the organism, and these integrations often follow algebraic rules: averaging, multiplying, and adding.

Empirical reality of cognitive algebra has been demonstrated through a new theory of psychological measurement. The effectiveness of this functional measurement theory is illustrated in this chapter by an experimental study of person cognition and in later chapters by experimental studies in many different domains of psychology.

Cognitive algebra addresses everyday cognition in everyday terms. It can also penetrate more deeply to measure nonconscious sensation and affect, a necessity for transforming everyday cognition into scientific theory.

The axiom of purposiveness embodies a functional perspective, in which cognition is represented in goal-directed function. Purposiveness becomes a scientific concept through representation as measurable, personal value. This functional perspective entails a new approach to many issues in mainstream cognitive psychology. Functional memory, for

example, differs markedly from traditional conceptions of reproductive memory. Affect and motivation, hostile terrain to much current cognitive psychology, are organic components of functional cognition. New directions appear in every area.
The theory of information integration is a unified, general theory. Generality appears in empirical applications across nearly all domains of psychology. Unity appears in the utility of the same concepts and methods across all these domains. The theory of information integration is not another promissory note; it is not only a manifesto but a working reality. Contributions so far are modest but real; they open onto a new horizon of psychological science.

Preface Chapter 2: COGNITIVE ALGEBRA

Cognitive algebra represents a basic mode of cognition. There are equations of mind in psychology just as there are equations of matter in physics. These equations of mind are algebraic rules for information integration.
Addition rules may be diagnosed by a *pattern of parallelism* in a factorial graph. *Multiplication rules* correspond similarly to a *linear fan pattern*. This pattern analysis simultaneously solves the two associated measurement problems, providing veridical scales of the stimulus variables and of the response. The parallelism and linear fan theorems of this chapter thus solve the problem of the three unobservables discussed in relation to Figure 1.1.
The ubiquitous *averaging rule* occupies a special place in cognitive theory. Under the special condition of equal weighting, it obeys the parallelism theorem, thereby allowing easy analyses. In the general case of differential weighting, it yields nonparallelism, thereby accounting for many results discordant with additive theories. Indeed, differential weighted averaging implies an opposite effects, scale-free test between adding and averaging processes.
Aside from the intrinsic interest of algebraic laws of mind, cognitive algebra has quantitative uses. It solves the long-standing problem of true psychological measurement, including both conscious and nonconscious concepts. These measures provide a new window on cognition. Not least important, these measures provide new tools for analysis of nonalgebraic cognition.
Conceptual implications of cognitive algebra are more important than the algebraic precision. Foremost is meaning invariance, strong evidence against entire classes of theories that argue for configurality and interaction, from person cognition to memory and language. Also, cognitive algebra makes affect and emotion integral components of cognition. Other qualitative, conceptual implications may be itemized:

1. Unified approach to social--personality (Chapters 4--7).
2. Assemblage, nonstage view of cognitive development (Chapters 6 and 8).
3. Integration psychophysics founded on psychological law (Chapter 9).
4. Cognitive, not normative, base for judgment--decision (Chapter 10).
5. Shift from reproductive memory to functional memory (Chapter 11).
6. Context and nonverbal informers integral to psycholinguistics (Chapter 12).
7. Fundamental place of value and multiple determination in all areas.

In each of these areas, cognitive algebra has led to a new way of thinking. At bottom, this approach represents a fundamental shift to focus on structure of the internal world. This focus has put the axiom of purposiveness on a scientific base, a foundation for a self-sufficient cognitive theory of everyday life.

Chapter 3 Preface: PSYCHOLOGICAL MEASUREMENT THEORY

A new theory of psychological measurement is presented in this chapter. It follows a new direction, in which measurement theory is an organic component of substantive theory. Measurement scales are thus derivative from empirical laws. This *functional measurement*

theory is not a mathematical promissory note but is solidly grounded in empirical studies of cognitive algebra.
Measurement of sensory qualities such as loudness and grayness has been controversial since the first proposal in 1860. Even more doubt has attached to measurement of concepts such as expectancy and blame, which lack a correlated physical dimension. Functional measurement theory has been reasonably successful with both kinds of concepts.
Two characteristics distinguish functional measurement. First, it provides a validity criterion for the measurement scales. This validity criterion is given by cognitive algebra, following the logic illustrated with the parallelism theorem of Chapter 2. Previous attempts at psychological measurement have either failed to provide validity criteria or have failed to satisfy them. Cognitive algebra, in contrast, has been empirically grounded.
Second, functional measurement places primary emphasis on continuous response measures. Continuous response measures have been shunned in measurement theory, in part because of biases so dramatically illustrated in Figure 3.1. Most workers, accordingly, sought to construct measurement theory using only choice or rank data. This is possible in principle, as with the monotone analysis method of functional measurement. In practice, however, it is exceptionally difficult and the practical outcome has been meager.
In measurement theory, the averaging rule has a unique role. It is disordinal in general, beyond the scope of other measurement theories. It establishes a two-parameter, weight--value representation as fundamental for psychological measurement. These properties, coupled with its empirical ubiquity, have provided a new foundation for psychological measurement theory.
The key to success lay in developing experimental procedures to eliminate biases in continuous response, thereby obtaining a true linear measure. This was essential for establishing averaging theory.
A primary function of measurement theory, in the present view, is to develop empirical procedures that can yield veridical continuous measures of response. Continuous response measures are essential for studying configurality, interaction, and the many integration tasks that do not follow algebraic rules. They are especially important with behavioral and physiological measures.

Preface Chapter 4: PERSON COGNITION

Information integration theory is a grounded theory of person cognition. Seven basic phenomena can be understood with a single theoretical principle in the following experimental studies. This work led to a new way of thinking, a functional perspective that embodies and actualizes the axiom of purposiveness.
A central issue concerns meaning invariance. Numerous theories of cognitive consistency have been proposed, based on the idea that separate informers in a person description interact to change one another's meanings. A strong test of the hypothesis of meaning interaction was provided by the parallelism theorem of Chapter 2. Meaning interaction implies systematic deviations from parallelism. The experimental studies revealed parallelism, contrary to the hypothesis of meaning interaction. The cognitive consistency theories could not survive the failure of their basic assumption.
Instead, the parallelism supported meaning invariance. Beyond that, it was the harbinger of a general algebra of person cognition.
Altogether, seven basic issues had to be resolved to put this theory of person cognition on good ground. Besides cognitive consistency, other issues also involved the hypothesis of meaning invariance. The much-belabored issue of primacy--recency, for example, was shown to make theoretical sense in terms of attentional factors. The interpretation in terms of meaning interaction, although originally plausible, was thus found also incorrect in the primacy--recency area. Similarly, the positive context effect---that judgment of a part of a

whole is influenced by the whole---was shown to reflect a halo integration process. The hypothesis of meaning interaction failed yet again.
The basic integration process of person cognition is one of averaging. The once-popular additive, summation theories were disproved with a paradoxical finding of opposite effects predicted by averaging theory.
The final outcome has been broad, solid support for a cognitive algebra of person cognition. Experimental analysis led to a unified treatment of all seven issues. This chapter thus represents a case history in experimental science.
Person cognition is a prime field for general cognitive theory. The cognitive processes studied in this chapter are basic in many domains, as will be seen in later chapters. A guiding theme is the functional perspective; cognitive algebra gives effectiveness to the axiom of purposiveness. The work summarized here thus constitutes a foundation that goes beyond cognitive algebra toward a unified theory focused on thought and action of everyday life.

Preface Chapter 3: UNIFIED SOCIAL COGNITION

Social psychology can be a science. This thesis, begun in the previous chapter on person cognition, is extended to *attitudes*, *attribution*, and *group dynamics*. A unified theory is shown to be effective across all these areas.
Attitudes, in the functional perspective, are knowledge systems. They function in construction of attitudinal responses in diverse social situations. This function often involves an averaging process, illustrated here with attitudinal judgments about U. S. presidents and with wife--husband interaction. This cognitive algebra has provided a new approach to many problems in the attitude domain, including motivation, measurement, and memory.
A novel contribution is the functional theory of memory, which arose in an early integration study. Attitude cognition could not be understood within a traditional conception of memory. Integration theory led to a functional conception of memory, grounded in the axiom of purposiveness.
Why did she act that way? represents a prototypical question in social attribution, which studies how people attribute causes to explain behavior. Such attributions have been shown to follow causal schemas of exact algebraic form in various situations. Other current theories have attempted rationalist formulations, which are inadequate, conceptually and methodologically, for analysis of attribution processes.
Group dynamics also exhibits cognitive algebra. Bargaining obeys a general social averaging theorem that quantifies compromise. Group cognition obeys rules like those for person cognition in the previous chapter. Of special interest is the family, the most important---and most neglected---social group.
The theory of information integration involves a new way of thinking. Comparisons with prominent theoretical alternatives in each of the three foregoing areas show that all ran aground through attacking multiple determination with makeshift methods. Functional measurement was effective in all three areas.
Fragmentation and compartmentalization are steadily increasing in social--personality psychology. Even within a single area, such as attitudes, numerous mini-theories go their separate ways, with little interaction and little generality of result. This fragmentation stems from old ways of thinking, which cannot handle the basic problems of multiple determination and personal value.
The theory of information integration makes possible a scientific treatment of everyday life in something like its own terms, grounded in the axiom of purposiveness. Although incomplete in many respects, information integration theory provides a unified, general approach in place of the increasing compartmentalization within social--personality psychology.

Preface Chapter 6: SOCIAL DEVELOPMENT

Two very different views of moral development are contrasted in this chapter: developmental integration theory and stage theory.

The influential stage formulations see moral development as a succession of stages, discrete and discontinuous, each with a distinctive moral character. Within each stage, moral thinking is controlled by a single organizing principle. Four or five such principles are claimed to explain all moral thinking. Study of moral development thus becomes a search for these principles; they promise great simplification in theory construction.

Developmental integration theory adopts a functional view: Morality is a class of biosocial knowledge systems. These knowledge systems have adaptive functions in assemblage of moral judgments and decisions in the diverse situations of everyday life. No precommitment is required regarding discrete stages, which indeed seem unlikely. Instead, it is suggested that moral ideas of early years remain functional in later life. Adult moral cognition thus involves assemblage of moral motivations and values from all periods of development.

With this difference in conceptual framework goes a difference in methodology. Stage formulations place primary emphasis on verbal protocols obtained in structured interviews. Developmental integration theory employs functional measurement, with simple judgments that require minimal verbal ability.

These two approaches yield very different results in studies of blame and fairness. Developmental integration theory reveals that young children have advanced, flexible capabilities for moral judgment---capabilities that have been denied by the interview methodology. The interview method is insensitive to moral cognition. Indeed, it presents false claims with great confidence in their truth, failing to see what functional measurement reveals.

Functional measurement reveals a moral algebra. For blame, in particular, the modal integration rule is averaging, invariant from 4 to 20 years. This rule invariance allows cross-age comparisons through measurement of idiographic moral values, which is essential for general moral theory.

A unified approach is needed, treating moral development as part of general social--cognitive development. Stage formulations, imprisoned in their conceptual precommitment, have shunned social cognition and judgment--decision theory. A cooperative approach is suggested, in which moral algebra provides a touchstone for developing valid interview methods---a needed methodological tool for cognitive theory of everyday life.

Preface Chapter 7: MORAL ALGEBRA

The idea of moral algebra goes back to Aristotle's rule for fair shares, and was made a cornerstone of the utilitarian philosophy of Bentham and Mill. Everyday language, similarly, often refers to moral obligation in accounting terms. But moral algebra has been merely conjecture. Without capabilities for handling two basic problems of moral theory---multiple determination and measurement of personal value---moral algebra was untestable.

Moral algebra becomes testable with functional measurement theory. Moral algebra has received considerable empirical support in applications to blame and punishment, duty, and fairness--unfairness. This provides a base for unified theory of moral cognition.

Fairness--unfairness, the main concern of this chapter, is notable for its multiplicity of comparison processes. Even simple fairness judgments involve three different comparisons: between deserving of two persons; between their rewards; and between the two persons themselves. These comparison processes follow exact algebraic rules.

Aristotle's rule of fairness is psychologically correct in its comparison structure although incorrect in algebraic form. The most popular modern rule is incorrect in both respects. The decision averaging rule of the theory of information integration is correct in both respects.

Comparison structure is studied further in three extensions: to multiple dimensions of deserving; to multiple dimensions of reward; and to multiple comparison persons. These extensions also follow a moral algebra, although in unexpected ways. Beyond its moral significance, fairness--unfairness may be a useful area for general cognitive analysis of comparison processes.

Moral algebra brings science into ethics. Moral thought and action depend entirely on moral values. Ethical philosophy, barring prescriptive views of value, has a certain hollowness because it has lacked capability for value measurement. Moral algebra makes values measurable, thereby providing a new line of attack on ethics. Also, moral algebra can go beyond measurement of values to confer some measure of scientific substance on concepts of the good and the bad, such as duty, obligation, temptation, sin, shame, blame, punishment, atonement, and forgiveness.

Preface Chapter 8: COGNITIVE DEVELOPMENT

Two developmental theories are compared in this chapter with respect to commonsense knowledge about the external world: developmental integration theory and Piagetian theory. The problem of stimulus integration is central to both theories, as shown in their basic experimental paradigms. Direct comparison of the two theories is thus straightforward.

Piagetian theory makes several interrelated claims: that children up to age 5 or 6 years cannot integrate two variables into a single judgment; that knowledge develops by discrete stages, each qualitatively different from its precursor; that algebraic rules are not possible until the final stage of formal operations, in the midteen years; and that stimulus integration in the final stage is reversible and mirrors physical law.

All these Piagetian claims are seriously incorrect. This is shown by experiments in developmental integration theory. Children even younger than 4 years can integrate very well, and their judgments often exhibit algebraic rules. In some tasks, indeed, young children exhibit true operational thought. Adult judgment, on the other hand, often disagrees with physical law.

Experimental applications of the functional measurement paradigm are given in four areas: time--speed, conservation, number, and probability. In all four areas, functional measurement has led to a picture of knowledge development radically different from that of Piaget. Children are not merely more advanced than Piaget claimed, but qualitatively different.

Isomorphism is the linchpin for Piagetian theory---isomorphism between the physical world and the final stage of development. This assumption also provided a framework for understanding the course of development, which must be interpreting as tending toward final isomorphism. But developmental integration studies show that Piaget's isomorphism assumption is fundamentally incorrect. Cognition differs qualitatively from Piagetian claims at every age. Piagetian theory is incorrect in its basic assumptions and needs to be replaced by assemblage theory.

Assemblage theory is a genuine alternative to Piagetian stage theory because it allows joint action of processes and abilities from all periods of development. Whereas stage theory requires all thinking within each stage to have one homogeneous quality, assemblage theory envisages thinking as generally heterogeneous, with components from all levels of development. Assemblage theory differs from stage theory already in Piaget's preoperational stage, and this difference becomes greater with further development.

Preface Chapter 9: INTEGRATION PSYCHOPHYSICS

Integration psychophysics involves a fundamental conceptual shift. The venerable concept of *psychophysical law* has been a historic misdirection, influential but barren. A shift is needed from psychophysical law to *psychological law*.

The senses are fundamental to thought and action, means whereby the brain constructs its remarkable internal representation of the external world. In the traditional conception of psychophysical law, this external--internal relation was assumed to rest on a single, simple mathematical function, the same for all senses. This assumption became taken for granted; the controversy was over *which* function was correct.

But this conceptual framework of psychophysical law never resolved its own central problem, namely, measurement of experienced sensation. For this, the psychophysical framework was inherently too narrow.

Adherents of psychophysical law assumed that Nature's order and law would be found in the sensory interface between the external and internal worlds. Integration psychophysics, in contrast, seeks order and law in the structure of the internal world itself. Of special significance is the algebraic structure of integration rules, or *psychological laws*.

Integration psychophysics was thus able to resolve the central problem of traditional psychophysics, namely, measuring experienced sensation. This can be done simply, as illustrated with the parallelism theorem of Chapter 2.

This resolution is not a mathematical hope but an experimental reality. This reality is demonstrated here with empirical applications to nine classical problems of psychophysics and perception.

Integration psychophysics has a broader horizon than traditional psychophysics. Multisensory integration, which is hardly amenable to representation in terms of psychophysical functions, is handled straightforwardly in two of the empirical illustrations. Context effects, often considered sow's ears in traditional psychophysics, can be made into silk purses in integration psychophysics. Nonconscious sensation, a neglected concept in psychophysics, can be defined and measured with functional measurement methodology.

Integration psychophysics can cooperate with sensory psychophysics, the other main branch of traditional psychophysics. Whereas sensory psychophysics follows a periphery-inward path, integration psychophysics follows a center-outward path. Sensory psychophysics, largely eschewing the psychophysical law, has made striking progress. It has difficulty with multisensory integration, however, and tends to ignore more cognitive processes. Functional measurement provides a grounded methodology for cooperative inquiry.

Preface Chapter 10: COGNITIVE THEORY OF JUDGMENT-DECISION

Cognitive algebra is a foundation for cognitive theory of judgment--decision. Algebraic models have often been conjectured, but they remained untestable conjectures due to lack of capability for psychological measurement. Functional measurement theory made it possible to demonstrate the reality of cognitive algebra in the judgment--decision domain.

The linear fan theorem of functional measurement provided the first general method for testing the elusive multiplication model for Subjective Expected Value. Similar multiplication models have done well in further studies. Sometimes these models agree with normative algebra, sometimes not.

The normative Bayesian framework was shown to be conceptually inappropriate to describe human judgment---by establishing the alternative decision averaging model of information integration theory. Averaging theory also furnishes nonprobabilistic disproof of the sure-thing axiom, once considered a cornerstone for judgment--decision theory.

A cognitive--normative antinomy troubles the judgment--decision field. The dominant normative approach prescribes algebraic models for optimal behavior in various tasks, and many hoped that these models would describe actual behavior. This hope has been repeatedly disappointed; cognitive algebra is real but it differs from normative algebra, mathematically and conceptually.

The normative models, however, were not really given up. Instead, deviations from the normative models were reified as ``biases'' and treated as psychological phenomena that needed explanation. This is misguided logic; the bias exists only by reference to a normative model---whose invalidity the bias demonstrates. This invalidity can hardly endow the bias with cognitive reality.

Information integration theory takes a positive approach to biases, in strong contrast to the negativism of the normative view. This point may be extended by noting that information integration studies had yielded basic evidence against three popular heuristics (representativeness, anchoring and adjustment, and availability) before they were first propounded.

Cognitive--normative cooperation is desirable, especially as regards values. The cognitive--normative antinomy is well illustrated by the makeshift character of value measurement in normative analysis. Normative models can be useful as prescriptions for optimal behavior, but these prescriptions typically depend on subjective values, outside the normative domain. Without values, the normative approach is hollow. Cognitive algebra can be a companion and aide because it can operate in this transnormative realm of values.

Preface Chapter 11: FUNCTIONAL MEMORY

Memory looks very different from a functional perspective. Traditional memory research is focused on accuracy---reproduction of specified material. The prototypical task is remembering a list of words. Functional memory, in contrast, is concerned with judgment and decision---assemblage of past experience and present stimuli to pursue present goals. The prototypical task of functional memory involves valuation of present stimuli by means of memorial knowledge systems, together with integration of informers.

This functional--reproductive distinction arose serendipitously in a 1963 study of memory in person cognition. Subjects received a serial list of trait adjectives that described a person; they judged likableness of the person and also recalled the adjectives. According to then-unquestioned conceptions of memory, the judgment of the person should have been determined by the recalled adjectives. The results showed otherwise; the functional memory of the person had storage different from that for the adjectives themselves.

Functional measurement theory can analyze memory. Under certain conditions, an integrated response can be dis-integrated to reveal its memorial structure. In the cited task, the recall curve shows recency, whereas the functional memory curve shows uniform primacy (see Figure 11.1). This contrast implies that the functional memory is distinct from the recall memory. Further, this measurement capability provides a basis for studying functional memory.

The functional--reproductive distinction is underscored by the concepts of redundancy and inconsistency. These have peripheral importance in traditional reproductive memory, but they are central in memory function. Much information we get in everyday life is repetitious; some of it disagrees with what we already believe. Valuation of incoming information thus requires reference to memory knowledge systems to assess redundancy and inconsistency.

Affect is basic in functional memory, as in our knowledge systems about our family, our colleagues, and our research. Affect is also basic in our beliefs and attitudes. Information integration theory provides a useful approach to this and other problems of memory function in everyday thought and action. Affect, attitude, belief, redundancy, and inconsistency are among the many issues that come to life in a functional approach to memory.

Functional memory is congruent to the axiom of purposiveness; the function of memory is to subserve goal-oriented thought and action. Functional memory is constructive and active, as recognized in the conception of an operating memory for online control of thought and action. Functional memory is thus unified with judgment--decision and other fields considered in previous chapters.

Chapter 12 Preface: ALGEBRAIC LANGUAGE PROCESSING

Cognitive algebra has many applications in language processing. The work of Gregg Oden, Dominic Massaro, and Shu-Hong Zhu, which underlies much of this chapter, ranges from phoneme perception through adjective quantifiers and prototype analysis to sentence understanding.

Meaning invariance is one major implication of cognitive algebra. Quantifiers have the same linguistic meaning in different contexts, as shown by the success of multiplication and averaging models. A quantifier will elicit different behaviors in different contexts, it is true, but it is a misconception to conclude that its meaning depends on context. The different behaviors can result from integration of an invariant meaning with the variable context.

Continuous language concepts have a natural home in functional measurement theory. True psychological measurement becomes possible for ``fuzzy'' concepts, such as class membership, ambiguity, and quantifiers. The theory of information integration provides a cognitive alternative to the normative approach of fuzzy logic, an alternative with greater generality.

Language parameters derived from cognitive algebra have many uses. Context becomes measurable, including nonverbal context; affect and value become integral to language analysis; qualitatively different language cues can be measured with a common unit; language parameters can be compared across subcultures and languages; prototypes can be shown to have cognitive reality; the thought--word relation becomes determinable.

Functional theory emphasizes communication functions of language. It focuses on reader/listener construction of meaning. Part of this construction is at psycholinguistic levels of syntax, semantics, and pragmatics. A further part depends on inferences from world knowledge systems outside the psycholinguistic domain. Cognitive algebra provides a unified approach that can address all aspects of this construction of meaning.

Pragmatics falls naturally within a functional theory. Of special interest are social knowledge systems for context-dependent inferences that help fill in what is unsaid and reduce ambiguity. Linguistic pragmatics can be extended to social pragmatics; attribution schemas and general person cognition become integral components of language processing.

Cognitive algebra may constitute a *language universal*. All language users face the same two basic problems of valuation and integration. The algebraic rules found here for language processing have appeared in most other areas of psychology. These rules appear to arise naturally, not induced by culture. Cognitive algebra may thus be a universal characteristic of language processing.

Preface Chapter 13: UNIFIED THEORY

The theory of information integration is unified and general. Generality appears in the spectrum of preceding chapters, from person cognition to functional memory, and from social development to judgment--decision and language. Unity appears in the applicability of the same concepts and methods across all these domains.

The unity and generality of information integration theory derive from three interlinked features: purposiveness; information integration; and cognitive algebra. Purposiveness and information integration, in different ways, are basic givens of thought and action. Cognitive algebra provides effective analysis of information integration; functional theory of value measurement gives a cutting edge to the axiom of purposiveness.

The axiom of purposiveness entails a functional perspective: Thought and action are oriented toward goals. Functional perspectives have been advocated by many psychologists, but most have remained generalities, disappointingly weak for scientific analysis. Functional measurement of value provides an effective base for functional theory.

The functional perspective leads to a focus on phenomenology of everyday experience. Phenomenology is a priceless starting point, but it is inadequate in two respects. It can be obstinately mistaken, and it can do little with nonconscious processes. Cognitive algebra can help phenomenology find and resolve its mistakes, especially through measurement of the nonconscious.

Cognitive algebra can thus help transform everyday knowledge into science. Nearly all the concepts considered in integration theory are taken from everyday experience. The successes of the algebraic rules, together with their failures, are steps in transforming these phenomenological entities into scientific entities.

The integrationist approach has yielded new ways of thinking in many areas: memory, language, belief formation, judgment--decision, psychophysics, cognitive development, moral judgment, social attitudes, person cognition, and others. In part, this stems from analytical power of cognitive algebra. In part also, it stems from a foundation in structure of the internal world. With this shift to internal structure, many areas take on broader life and new vitality.

Cognitive algebra is not an end, but a new beginning. It can go beyond itself to help study nonalgebraic aspects of cognition. Indeed, the conceptual implications of cognitive algebra are in many ways more important than the quantitative capabilities, as itemized in the final section, *Beyond Cognitive Algebra*. Information integration theory is incomplete in many ways, but it has considerable potential for analyzing structure of nonalgebraic cognition.