the contribution it makes to the methodology of behavioral research by emphasizing a frequently overlooked source of potential bias, but also for what it demonstrates about the complexity of human behavior, especially behavior in the presumably restricted conditions of the laboratory. Yet it may not be just the number of factors, taken singly or in interaction, that makes behavioral research so difficult. In much behavior, although the total variation for a group of subjects seems to involve small average contributions from many factors, such as volunteer status, the contribution of any one factor may be large for some subjects and small for others. Perhaps behavioral scientists are too ambitious in seeking to understand all the myriad kinds of behavior they have observed. Perhaps it would be wiser to begin with the fundamentals, establishing definitively the relationships and parameters in those situations where the behavior is primarily determined by one or two factors. Perhaps behavioral scientists think in too large terms when they observe responses stemming from complex decision processes, when they study the relationship between sociability and volunteering, for example. Perhaps they are working at too abstract a level of analysis: there may be greater regularity in behavior analyzed at the level of moment-to-moment acts than in the longer sequences construed in the more global and multifaceted terms so prevalent today in both everyday and scientific descriptions of behavior.

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Applications of Formalism

Contemporary Developments in Mathematical Psychology. DAVID H. KRANTZ, R. DUNCAN LUCE, RICHARD C. ATKINSON, and PATRICK SUPPES, Eds. Two volumes. Vol. 1, Learning, Memory, and Thinking. xvi, 300 pp., illus. $9. Vol. 2, Measurement, Psychophysics, and Neural Information Processing. xviii, 468 pp., illus. $14. Freeman, San Francisco, 1974.

To many, "mathematical psychology" refers to a field of psychology informally founded in the 1950's by such people as R. R. Bush, C. H. Coombs, W. K. Estes, R. D. Luce, G. A. Miller, and P. Suppes. This field is concerned with mathematically based research on such matters as learning, concept identification, memory, latency, signal detection, and axiomatic formalisms in measurement, choice, and psychophysics. The *Journal of Mathematical Psychology* was founded in 1964, and the annual mathematical psychology meetings were begun in 1967. All four editors of the two volumes under review have been closely associated with both the journal and the meetings. It would seem quite natural that in 1974 a progress report detailing the knowledge gained in two decades of active research would appear. This book is not exactly that, however. The first volume does consist mostly of essays that concern research that is historically tied to the work in statistical learning theory of the 1950's done by C. J. Burke and W. K. Estes and by R. R. Bush and F. Mosteller, but the second and longer one covers more mathematically complex topics whose roots extend into the 1800's to the work of such notables as Francis Galton, Gustav Fechner, Hermann Helmholtz, Ewald Hering, and Ernst Mach. The first third of volume 2 deals with research in psychometrics, which is clearly outside the mathematical psychology established in the 1950's, and the last third deals with work in sensory psychology and neural modeling. Only the middle third, which concerns measurement and psychophysics, would be considered by most to represent approaches that evolved from the 1950's work, in this case from that of Suppes and Luce.

The aim of the two volumes, according to the editors, is to attempt to define by example the concept of progress in mathematical psychology. However, the 18 papers they contain range from general surveys, such as J. G. Greeno's comprehensive essay on Markov models for learning and memory, to expositions of new theoretical developments, such as M. V. Levine's interesting essay on geometrical interpretations of psychophysics. The lack of uniformity in level of presentation and the absence of editorial discussion of the essays leave the task of assessing "progress" to the reader. In addition, some of the essays reflect an unfortunate current tendency in psychology to encourage a profusion of book chapters that are largely rehashes of previous work. Without the demands of economy that a journal makes, it seems that some authors have lost the knack for succinctness. On the other hand, several of the essays are very nicely done.

In volume 1, the considerable literature devoted to how subjects identify Boolean hypotheses from classified instances and noninstances is discussed in three essays. The many "dichotomies" and "issues" that have emerged from this work and are frequently cited seem to this writer to leave us far from any convincing progress. However, because of the paucity of observable behaviors in relation to unobservable processes in memory and thinking, they are among the most difficult phenomena to model convincingly.

Noticeably absent or at a minimum in volume 1 is discussion of work in psycholinguistics. Both automata models and semantic network models have received and will continue to receive much attention. The idea that given models can or cannot *in principle* accomplish given behaviors, nicely illustrated in M. Minsky and S. Papert's work with perceptrons, may prove to be a more fruitful approach to "higher processes" than the traditional one of fitting the statistical details of data collected in simple settings. Many have tried to extend their models for simple settings to more complex ones with little success, and the resulting profusion of vaguely argued systems diagrams and flow charts suggests a need for another approach.

Rather curiously, Estes and Suppes present some of their work on the foundations of stimulus sampling theory which was done originally in the late 1950's and which, though well known to insiders, heretofore has been available only in technical report form. The presence of this essay in the *Contemporary Developments* volumes certainly will fuel the mind of a reader attempting to assess "progress" for himself. In a somewhat related essay, M. F. Norman impressively shows how some high-powered techniques of mathematical analysis can be brought to bear on several vintage issues in discrimination learning. Unfortunately the techniques seem limited to relatively simple learning paradigms.

In the first third of volume 2 the psychometric subjects of factor analysis, test theory, and multidimensional scaling are discussed in three essays. Although this writer is not well equipped to assess overall progress in that field, it is clear that great advances have been made in devising usable, informative, and widely applied multidimensional scaling methods.

D. H. Krantz's essay clearly makes the case that progress in providing axiomatic formalisms for many of the simple measurement, choice, and psychophysics paradigms has occurred. It also includes a pretty application of Grassmann structures to the color matching paradigm based on an analogy to the vector resolution of forces in three dimensions. The essay by J. C. Falmagne on foundations of Fechnerian psychophysics presents additional evidence for progress in this area. In addition, Falmagne presents several arguments to the effect that much prior work in psychophysics aimed at discovering a "scale of sensation" may have been frustrated by the possibility that subjects utilize different

aspects of the representation of a physical input to comply with different psychophysical tasks. He seems to be aiming toward a processing theory of psychophysics rather than the "true score" representation that seems to this writer to plague much of the formally interesting work in this area.

The second volume concludes with three comprehensive essays on vision, audition, and holographic memory models. The interesting way in which neural constraints interplay with mathematics is nicely illustrated, and these essays fill a void in the mathematical psychology literature.

Although the *Contemporary Developments* volumes do not accomplish their goal of assessing progress in the field, they do foreshadow a broader vision of what constitutes mathematical psychology. I do not know of any better source for acquainting readers with what has happened and what will happen in the applications of formal thinking in psychology.

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After Pavlov

Biology and Neurophysiology of the Conditioned Reflex and Its Role in Adaptive Behavior. PETER K. ANOKHIN. Translated from the Russian edition (Moscow, 1968). Samuel A. Corson, Ed. Pergamon, New York, 1974. xviii, 574 pp., illus. $51. International Series of Monographs in Cerebrovisceral and Behavioral Physiology and Conditioned Reflexes, vol. 3.

Drawing mainly on classical Russian neurophysiology and over 40 years of experimental research, the late P. K. Anokhin here offers a synthesis of theory and data bearing on the nature of the conditioned reflex. Although published originally in 1968, the book will still be of interest to Western scholars. In it English-language psychologists and neuroscientists are treated to a thorough and unhurried survey of the study of higher nervous activity in the post-Pavlovian era by one of the most eloquent and influential workers in the Pavlovian tradition.

Heretofore, access to these developments has been piecemeal, being primarily by way of the reviews and surveys of the late G. Razran and the published proceedings of those symposia (starting around 1960), in which Anokhin invariably participated, which ushered in the age of East-West détente in the neurosciences. Though valuable, such sources do not adequately reveal to Westerners the issues that have united and divided our Soviet colleagues. Konorski's books and translations of works by Bykov, Luria, and Sokolov provide clues, but in many ways these works seem too adulterated by Western viewpoints for this purpose.

Anokhin shows no lack of familiarity with Western neuroscience, but, although he attempts with varying success to incorporate information gathered from round the world, most of his arguments rest on the work of his own distinguished collaborators, who work in a wide range of fields including behavioral biology, developmental neurobiology, cardiovascular and respiratory physiology, experimental neurosurgery, clinical neurology, and electroencephalography.

Anokhin's thesis is that the conditioned reflex is a supreme expression of the adaptive evolution of the nervous system. Like all adaptive behavior, conditioned reflexes arise from a synthesis of two types of afferent information: input from the environment, with great emphasis on contextual factors, and feedback ("reverse afferentation"). These produce the pattern of preparatory reactions which constitute the conditioned reflex and assure its appropriateness to contingencies relevant to the survival of the organism.

I was struck by the similarity between Anokhin's viewpoints and those favored by Western cognitive psychologists and cyberneticists. For example, to Anokhin the essence of acquired adaptive behavior is the formation of an "action acceptor" responsible for harmonizing primary environmental information with feedback. The action acceptor is very much like the "plan" formed through TOTE (for "test, operate, test, exit") in the schema enunciated some years ago by Miller, Galanter, and Pribram. In short, Anokhin's conclusions about the processes involved in conditioning should be familiar to and sympathetically received by most learning theorists.

Equally comfortable are Anokhin's views on "internal" or conditioned inhibition. The Pavlovian dogma that inhibition originates at the analyzer of the conditioned stimulus is discarded. Instead, inhibition is regarded as resulting from the excitatory influence of a parallel but incompatible "functional system," a viewpoint shared by Konorski and others. As applied to alimentary conditioning in dogs, the inhibitory effect of nonreinforcement in the earliest stages of extinction or differentiation arises from the orienting reaction that inevitably accompanies "discordance" at the action acceptor. Discordance is essential for further development of a "secondary" or "indirect" inhibition brought about during the formation of a new action acceptor appropriate for nonreinforcement. Any procedure that minimizes discordance, such as Terrace's method of "errorless" discrimination learning, will yield little or no conditioned inhibition.

Anokhin's views on specific physiological mechanisms underlying conditioning and inhibition boil down to these essentials: Conditioning consists fundamentally of a molecular reorganization within the neurons that make up the functional system of the conditioned reflex. The energy expenditures necessary for discordance and conditioned inhibition involve a circuit from frontal cortex through hypothalamus to the reticular formation. Inhibitory influences might be of a hyperpolarizing nature when acting on effector units or of a depolarizing nature when high rates of synaptic input are involved. The latter mechanism is termed "pessimal" or Wedensky inhibition and is treated at some length by Anokhin in discussing dominant states of the nervous system.

As often as not, the train of logic from the experimental evidence presented to the particular conclusion it is meant to support becomes derailed in translation. It is the rich interplay with Russian neurophysiological traditions and schools of thought that lends force and urgency to Anokhin's arguments. This is not a reference work; to be fully appreciated or comprehended it must be read seriatim. It is a handsome volume, profusely illustrated with helpfully captioned figures. It includes good indices, a glossary, and an invaluable bibliography.

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Perceptual Psychophysics

Perception. Essays in Honor of James J. Gibson. ROBERT B. MACLEOD and HERBERT L. PICK, JR., Eds. Cornell University Press, Ithaca, N.Y., 1974. 318 pp., illus. $14.50.

In the concluding section of his innovative text *The Senses Considered as Perceptual Systems*, J. J. Gibson wrote, "When the senses are considered as perceptual systems, all theories of perception become at one stroke unnecessary. It is no longer a question of how the mind operates on the deliverances of sense, or how past experience can organize the data, or even how the brain can process the inputs of the nerves, but simply how information is picked up. . . . The individual does not have