

ments will be presented to show that this represents the fundamental situation in cognition theory, and some of the implications therefrom will be discussed.

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J3. Entropy, Organization, and Physical Models of Biological Systems. JEROME ROTHSTEIN, Edgerton, Germeshausen and Grier, Inc., Boston, Mass.—Apparently unique generalized entropy ( $GE$ ) is described permitting quantitative discussion of information and organization in physical systems. Behavior ( $B$ ) is defined in terms of coupling ensembles (stimulus-response, input-output), and  $B$  characterized by its  $GE$  ( $GEB$ ). The black box ( $BB$ ) generating  $B$  has a  $GE$  and is considered one of a set of objects capable of generating  $B$ . Order the set according to the  $GE$ 's calculated with purely internal constraints relaxed. This  $GE$  is defined as the complexity of the  $BB$  ( $BBC$ ); its minimum is a function of  $B$  only.  $BBC$  minus  $GE$  calculated with internal constraints operative is amount of organization ( $BBO$ ). Minimum complexity increases monotonically with  $GE$  of  $B$  ( $GEB$ ) and  $BBC \geq GEB$ . Call a  $BB$  with measuring and effector equipment, internal programming and motor, a well-informed heat engine ( $WHE$ ); any operationally defined  $B$  is realizable in principle with some  $WHE$ . Physical models of biological systems are thus, in a sense, always possible. Crucial question: Can one probe deeply enough to specify biological  $B$ ? Vitalists say no, mechanists yes. *Elsasser* asks if sufficient complexity bars such probing and answers affirmatively. While quantum theory imposes such bars, they may occur at irrelevantly detailed levels of microscopic description. Distinguish reducible and irreducible complexity, the former describing systems analyzable into less complex sub-systems. If biological  $B$  has  $GEB > BBC$  for the set of maximally reduced sub-systems, deeper analysis is barred. As instability against thermal fluctuations discriminates against irreducible, in favor of reducible (redundant) systems, deep probing may be possible.

J4. The Use of the Mnemotron for Biological Data Storage, Reproduction, and for an Average Transient Computer. M. CLYNES AND M. KOHN, Rockland State Hospital, Orangeburg, N. Y.—The mnemotron is a new precision device which allows biological data to be stored and reproduced in conjunction with an ordinary audio tape recorder. It utilizes pulse frequency-modulation techniques which prevent errors due to the tape mechanism from being multiplied, as in normal frequency-modulation techniques. Data may be recorded at different tape speeds and may be speeded up or slowed down as they are reproduced, with an accuracy of better than one percent. The mnemotron occupies little space, and weighs less than two pounds per channel of information, and is thus

readily portable. This inexpensive method may prove to be useful for many different applications. As many as four different variables may be recorded and reproduced simultaneously using a stereophonic tape recorder. As well as reproducing the data in analog form, the mnemotron can be used to convert the data to digital form in conjunction with an electronic counter. A special application is its use in a computer of average transients ( $CAT 1$ ). Transient behavior of biological variables, which is small in amplitude compared to the general variability and in the same frequency range, may be analyzed through averaging methods such as those developed by *Barlow*, et al., *Shipton*, and more accurately by the ARC computer at MIT. While the ARC computer has the advantage of greater accuracy and real time computation, its high cost prevents widespread use. The combination of a mnemotron tape recorder unit with some readily available commercial instruments provides high accuracy because of the digital method, is comparatively inexpensive, but does not compute in real time. On the mnemotron recorder, the variable (e.g.,  $EEG$ ) is recorded as a modulated pulse frequency, varying within a range of 5000 to 10,000 pps. On a second track time slicing pulses are recorded, say 100 for each transient using a gated pulse generator.<sup>1</sup> For analysis, on playback, a preset counter selects the  $n^{\text{th}}$  timing pulse for each transient which opens a gate to an electronic counter. This counter then counts the signal pulses between the  $n^{\text{th}}$  timing pulse and the  $(n+1)^{\text{th}}$  timing pulse, which closes the gate. This occurs for all transients, thus adding up the counts. The total count at the end of a run is the sum of the  $n^{\text{th}}$  slices of all transients. Similar runs are made for all other slices by setting the preset counter to successive steps. The total count for each run is plotted against delay time giving an outline of the average transient. The method eliminates the need for analog methods with their inherent errors. Errors in tape speed have no effect, since the timing pulses are recorded on the tape. The digital counting of pulses achieves single count accuracy of a total count which has no limit, but in practice may be as high as 100,000. Analysis involving signal to noise ratios of 1 to 100 may be easily achieved.

<sup>1</sup> Tektronix.

J5. Application of Feedback Concepts to a Rat Experiment. W. POWERS, Physics Unit, V.A. Research Hospital, Chicago, Ill.—An experiment on avoidance behavior reported by *Verhave*<sup>1</sup> is analyzed in terms of a generalized block diagram developed by the authors and others in connection with a general feedback theory of behavior. Equations are developed to describe the quasi-static transfer function of the environment, and to describe the hypothesized system (within the rat) responsible for the behavior. Primary assumptions about the rat are: (1) The rat behaves like a feedback system con-