Introduction

Since my last book (Pask, 1961) large changes and advances have taken place in cybernetics (or, equivalently, apart from a slightly different orientation) in general system theory. Similar transformations have also taken place in the structure, interpretation and methodology of the special fields of study with which cybernetics as an interdisciplinary pursuit is chiefly concerned. These transformations have the magnitude and coherence of a renaissance like phenomenon; so far as I can see they have no particular national boundaries and they are typically fostered by rather small groups of people, closely knit enough to catalyse conceptual developments, and interacting with one another across the usual geographical and cultural dividing lines.

One pragmatically crucial feature of cybernetics or general system theory is to provide a language in which this interaction can take place. It was the intention of the pioneers (Ashby, Beer, Weiner, McCulloch, Svoboda, Glushkov, Ivahnenko, Bateson, Waddington, Von Bertalanffy, Rapaport, Von Neumann, Von Foerster, and Rashevsky) that this should be so. The theme of Margaret Mead (at the General Systems meeting in Vienna in 1972) that it *is* so and the responsibility for this happy development lies, though it is rarely acknowledged, with a body of scientific coordinators; people with a flair for organisation as well as research; for example Boulanger and Hermann (in cybernetics) and their counterparts in the field of general systems.

The scope of the 'renaissance phenomenon' is very wide. For example it involves architecture, molecular biology, genetics, epistemology, even physics. But ethology, the social and psychological sciences, together with computation and information science are more overtly and deeply implicated than the others. This book makes no attempt to give a truly comprehensive picture of what is going on and touches only incompletely upon the fields that are surveyed (psychology, social science, teaching and training, the description of tasks and bodies of learnable knowledge, some facets of computation). I decided (after some efforts to write in a more general vein) to recount, for the most part, only research in my own laboratory in which I have directly participated. On the one hand, due to a generalist inclination, these researches, theoretical developments and methods have spanned quite a wide spectrum so that my own journey is representative of other people's voyages; on the other hand there are few things quite as tedious as books full of dilutions and regurgitations of work that ought to be read in the original. It is certainly not claimed that the examples employed to point out salient developments are optimum in any absolute sense; many colleagues have more elegant or incisive demonstrations but, like a good guide book (Egon Ronay's *Guide to Food and Wine* or Kate Simmond's *Guide to London*) the material is first hand and unashamedly personalised. The reader who likes to do so may use the book in this way, as a guide book to cybernetics or general system theory.

Whoever uses the book as a guide is cautioned of some outstanding but easily remediable deficiences. The chief empirical content is concentrated in two fields: (a) The acquisition of skill, which is intimately related to issues of selective attention and the mechanisms of long and short-term memory (Chapters 5–8; parts of Chapters 10 and 11), (b) intellectual and symbolic learning of the kind encountered in schools and similar institutions (Chapters 9, 10 and 11). So far as area (b) is concerned, the coverage is adequate, in view of the fact that educational problems are widely discussed and commonly encountered. Area (a), however, is treated, almost exclusively, from a limited point of view, namely, the development and application of cybernetic/system-theoretic experimental methods and means for measurement or regulation.

That is certainly not all of the story. The precedent for a cybernetic/system-theoretic approach to experimental psychology was set by Craik, more than 30 years ago; mostly in area (a). The concepts and achievements are vividly portrayed in his collected essays (Craik 1966; Ed, Sherwood). Since those days, cybernetic disciplines, notably information theory, have been applied very extensively. No attempt is made to cover the ground staked out by area (a) because two authoritative books already do so; namely, Broadbent's *Decision and Stress* (Academic Press, 1971) and Welford's *Fundamentals of Skill* (Methuen, 1968). The scholar should consult both of them; they fill the gap already noted and also give another, entirely compatible, perspective upon the whole field. Both books use cybernetic (information theoretic) techniques to explain particular psychological phenomena (vigilance, the division of attention, memory and recall). In contrast, this book insofar as there is any overlap, is written from a cybernetic but global point of view; for example, to pick out generally useful experimental or regulatory devices. Moreover, both Broadbent and Welford deal (in an instructively different manner) with the important issue of 'signal in noise' measurement and 'receiver operating curves', which are merely mentioned in the present volume.

Let us turn to cybernetics/system-theory itself, rather than the cybernetics/system-theory of human beings.

Amongst other changes it is fair to say that the original definition of what cybernetics is about has, to some extent, been modified. Weiner's definition, 'control and communication in the animal and the machine', still stands, but only provided that communication is given a broad enough connotation (roughly the one he gave) and that the notion of 'machine' is generalised to cover some quite unusual types of processor that bear little direct relation to general purpose computers as commonly used at the moment.

Taking a broader view, the emphasis has shifted in several ways, as follows.

1 In dealing with *systems* of any kind, cybernetics is primarily concerned with establishing isomorphisms (one to one correspondences) rather than the validation of propositions that are true (or have a chance of being true) or else are false. The basic mode of argument and development involves analogy. Strict analogies of which isomorphism is a special case. The analogy expressed or represented in the language employed to account for events is a *metaphor*. In this sense, cybernetics is the science or the art of manipulating defensible metaphors; showing how they may be constructed and what can be inferred as a result of their existence.

2 Isomorphisms, and material analogies of a less complete variety, are ubiquitous in physical science and technology and are essential to its progress; for example, the isomorphism between an operating electrical circuit and a hydraulic system, and between a plan (for a building) and the various artifacts that might be born of the plan. Further, apart from the operational use of analogy, which everyone relies upon in practice, arguments by analogy mark major innovations (and minor innovations as well for that matter). Polya's (1966) comments on this issue are particularly illuminating; readers who prefer to think in broader terms rather than the esoteric language of science may like to note how often Schneidmann's 'modes of concludifying' constitute analogical arguments.

It is true, but less commonly recognised that correspondences of this type and the arguments based upon them lie at the root of reflective and relativistic schemes, i.e. they are bound up with the activity of a *participant* observer rather than a classical external observer. These notions are developed at some length. We also have occasion to draw strict analogies, for example, between perceptual motor and cognitive skills, valid under a particular class of model. But the full gist of the discussion is exhibited in the next volume, where it is possible to detail the *participant* languages in which analogies of one kind or another play much the same role as propositions in a conventional language.

3 Cybernetics approaches a problem from the general to the particular rather than vice versa. The distinction is especially obtrusive in the context of computation where (traditionally) a large program is built up, by the programmer, from unitary instructions. In contrast, programming languages such as PLANNER or MICROPLANNER take basically global statements (of the kind 'achieve a goal by any method at the machine's disposal') that are qualified in so far as certain operations or methods are to be excluded. This orientation will be evident throughout the book, without specific mention, and is often contrary to the tenets of reductionism; though it is not in the least measure 'sloppy'.

4 In this connection the word 'goal' has undergone very appreciable revision. It used to be popular to think of *goals* as goal *states*. Nowadays, at least in the context of cybernetics, the goal is interpreted as a class of intentions or processes. Under this caveat it is possible, without difficulty, to posit *underspecified* goals (Pask, 1970a). Since underspecified goals are in the majority, *purpose* no longer has the singlemindedness of the prophet Job, so ably criticised by Bateson (1972) in *Our Own Metaphor* or Brodey in numerous publications.

5 Perhaps the most important mathematical tool is the theory of self reproducing machines. Burkes (1969) argues, for example, that whereas Wiener emphasised feedback regulation, due to his preference for a certain brand of mathematics, Von Neumann emphasised the theory of reproductive automata (noting that any such machine contains masses of feedback loops). So, for example, the idea of stability can be represented as a reproductive act that maintains a stable entity or, as an alternative, the entity can be regarded as stabilised by certain kinds of feedback. The approaches, in other words, are not incompatible, by virtue of which Wiener's (1954) theory of self reproduction is itself expressed in these terms.

6 The journey takes us into the territory of artificial intelligence but scant justice is done to the elegant concepts developed in this field. Other people's programs are often far more intriguing than our own; especially if the reader likes to view the intelligent operations in a restricted field, such as scene recognition. Hence, this book can be usefully augmented by further reading and the journal *Artificial Intelligence* and the series *Machine Intelligence* are particularly germane. As an overall dogma I see no need to use the qualifier 'artificial'. If a system is intelligent (more interestingly, if it evidences the exercise of intellect) it may be biological or not. Biological computations, executed in the brain as processor, constitute very special and interesting cases of intellect pure and simple.

Many other points can be made and come out in context. For example, there is increasing emphasis on the logic of distinctions (Spenser Brown, 1971), temporal logics as conceived by Gabbay (1972) and Rescher and Urquhart (1971), and the logic of norms (Von Wright, 1966), commands and questions. These and other developments underlie the entire argument. They are mentioned but not fully exhibited until the next volume.

7 Two of the original concepts of general system theory have recently been rescusitated (there is an admirable discussion in Ackoff (1973). The first of the two concepts is that whereas causal argument considers necessary and sufficient (or double implication) conditions, system theory/cybernetic argument deals primarily with a logic of necessary conditions (Singer's producer/product relations; alias the goal relations in Somerhoff, 1969). This notion underlies the more sophisticated treatment of *goals* and *intentions*; conceivably, partly specified intentions.

The other concept, of about the same importance, is the presupposition of a systematic universe. There is a tacit assumption that things, objects, and other elementary entities are interdependent (rather than being isolated units, which is the assumption behind the majority of sciences). Further as a result of their interdependence (equisignificantly, of the supposition that things, objects, and so on are not really unitary) these entities form *systems* and it is systems which may be observed and manipulated.

8 In his otherwise excellent book *Symbols, Signals and Noise* Pierce (1962) makes acid, even pejorative, comments upon the status of cybernetics. There is more than a grain of truth in his remarks. Much of the literature either consists of original piffle or diluted recapitulations of original work by commentators who are usually unaware, directly, of what was done.

This book is open to much the same criticism. It may be trite and trivial; surely it is designed to minimise technical mathematics and (so far as possible) equations etc. are confined to the appendices. Obviously I do not think it is trite and trivial (the reader must judge for himself) and it is, at any rate, original (not an unmixed blessing because the discussion is specific and patchy by virtue of it). However, I am thwarted by lack of space, and have made liberal use of reference to a further volume which contains the more recent and exciting developments for which this material is an essential foundation. This expedient is justified by the fact that the work in question is either in progress or has been fully reported in other monographs and papers. All the same I find the journey, even up to the point reached in this volume, quite enthralling and hope the reader will share that fascination.

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