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Cybernetic explanation and development

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Abstract This essay reports work in cybernetics that it is believed can shed light on methodological and conceptual issues in the study of child development. To do so, cybernetics is placed in the larger context of the philosophy of science, drawing particularly on the work of Frederick Suppe and Nicholas Rescher. The concept of explanation in cybernetics is used to elucidate controversies concerning “mechanistic” and “organismic” types of explanation. An account is given of several models that appear to be of use in explicating the concepts of development, self-organisation and morphogenesis. Finally, the distinctions between first- and second-order cybernetics (due to von Foerster) and taciturn and language oriented systems (due to Pask) are invoked to encompass the social dimensions of child development.

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Prologue
The bulk of this essay was written in 1983 when I was studying at the University of London’s Institute of Higher Education in order to become an educational psychologist. Professor C.B. Hindley read and marked the essay and encouraged me to seek to have it published. However, I wasn’t entirely happy with it as it stood and promised myself that one day I would rework it. I have finally kept that promise.
My intention in the essay was to address conceptual and methodological issues in the domain of child development, looking to the philosophy of science in order to do so from first principles. I already had a background in cybernetics (I completed a PhD in that subject at Brunel University in 1976). In my reading, I discovered that cybernetic and system theoretic concepts were, at that time, just beginning to have some influence in both developmental studies and the philosophy of science. The essay then evolved into being a more ambitious discussion of the nature of “cybernetic explanation” and a reporting of recent developments in cybernetics and systems theory, relevant to studies of child development.

The reworking has chiefly taken the form of the tweaking and tidying of arguments. I was pleased to see that much of what I reported as “recent developments” is still current and “newsworthy”. To have brought the reporting up to date would have been a major undertaking, a possible project for the future. However, some more recent work ought to be flagged. The breakthroughs in the formal modelling of dynamical systems is an outstanding example (Gleick, 1987). There has been an associated growth of interest in the study of “complexity”. I was pleased to see I had already featured one key contributor, John Holland, quite centrally in my discussions. His more recent work is presented in Holland (1999). Other texts, representative of more recent work, include Kauffman (1993), Prigogine and Stengers (1984) and Levy (1992).

Since writing the essay, with its discussion of models for the “evolution of ideas”, Richard Dawkins’ concept of a “meme” has become particularly popular as a focus for discussion (see, for example, Blackmore, 1999).

From within cybernetics, there have been a more extended discussion and development of constructivist epistemologies and ethical issues (see, for example, von Foerster, 1993). There has also been a proposal for the explicit extension of the ontological domains of interest to cybernetics to include the values and intentions of observers (Stewart, 1989), particularly relevant, for example, to my discussion of the concept of “good parenting”.

I allude in the essay to the central problems of “meaning” and “signification” in understanding social development and a child’s “acquisition of language” and emergence as a “conscious individual”, as addressed, for example, in the classic works of Jean Piaget, George H. Mead and Leo Vygotsky. These topics remain beyond the scope of my discussions. Recent mainstream work in child development is well represented by Nelson (1999). For an example of the application of “cybernetic explanation” to these topics, see Maturana (1995).

References
Cybernetics transforms language into an exchange of news (Heidegger, 1978).

Introduction
In essence, this essay has the form of a newsletter. Any originality resides in the bringing together of “news items” from a range of sources. I am conscious that my attempts at synthesis are not fully adequate but I hope I have achieved something more than a mere “pot-pourri”.

My main aim is to report work in cybernetics that can shed light on methodological and conceptual issues in the study of child development. To do so, I have had to place cybernetics in the larger context of the philosophy of science. Section one draws on the work of Frederick Suppe who has attempted, in a most thoroughgoing and masterful manner, a summary of the state of the art. As someone who has been immersed in cybernetic ideas for more than a decade, on reading Suppe I was again and again surprised by the extent to which conventional philosophy of science has failed to be influenced by cybernetics. Perhaps this is because, until recent times, philosophers of science have tended to focus their attention on the physical sciences, perhaps also because, whilst cybernetic models and methods have permeated the social and biological sciences quite thoroughly, there was, from the outset, a conservative reaction that objected to the grander claims made by cyberneticians, that here indeed was a fundamentally new science that unified the extant sciences from a higher order perspective.

As a useful bridge, in section two I briefly review the contributions made by Nicholas Rescher. His work is of interest for two reasons:

1. as a philosopher of science he appears, from my reading at least, to begin where Suppe leaves off, tackling those problems and issues which, in his summary, Suppe considers to have priority in future development;

2. Rescher makes explicit acknowledgement to having been influenced by both systems theorists and Jean Piaget.

Section three is very much a “pot-pourri”. In its several subsections I elaborate further the concept of explanation in cybernetics and, in particular, look at the conceptual issues raised in studies of child development with respect to the form, merits and status of so called “mechanistic” and “organismic” types of
explanation. I review various attempts at *rapprochement*, including those advocating a systems approach and/or “dialectical synthesis”. The chief objection I raise is the lack of a clear explanatory model in the approaches cited, having previously insisted that at the core of cybernetic explanation is just such a model. In a sense, I am too harsh, for one of the key ideas accepted by cyberneticians is that, at the end of the day, their discipline is fully reflexive. By that I mean that an aim of cybernetics is to model (explain) the observer to himself. Unfortunately, man, as a species of self-organising system, is necessarily self-transcending. His search for an understanding of himself is coextensive with his creation of himself. Such a process has no end. The one, true explanation cannot be found. As Couffignal (1960) has expressed it, cybernetics is an art, “l’art d’assurer l’efficacité de l’action”.

In an earlier paper (Scott, 1974), I captured this idea in the aphorism that “Cyberneticians manipulate metaphors”. Later, in the writings of Hannah Arendt, I came across the Kantian distinction between meaning and truth: we ascribe meaning to ourselves and our worlds; we move towards or into truth. With the acceptance of these essentially Wittgensteinian limits to what may be said, modelled or explained, one can still look for useful models and not be blinded by what Theodore Adorno, in his aptly titled essay “Negative dialectics”, refers to as the “magical aura” of words (Adorno, 1973). Accordingly, I proceed to give an account of several models that appear to be of use in explicating the concept of development. The descriptions are necessarily cursory and, as I am well aware, are far from being an exhaustive catalogue. I would like to have said more about the ways in which C.S. Pierce, for one, anticipated contemporary thought and issues. I would like to have had opportunity to do more than sketch the contributions of the cyberneticians, Pask and Von Foerster, whose work on cognition is explicitly concerned with epistemology and the philosophy of science. I have attempted reviews of their work elsewhere (Scott, 1979, 1980, 1982).

I would like to have said more concerning technical problems of modelling, by simulation, concurrent, interactive processes (an example of such a simulation is described in Scott, 1976). Perhaps, most of all, I would like to have addressed the particular issues to do with signification, representation, language and social life and thus brought the main stream of work on child development more clearly into view, but my account had to end before becoming too unwieldy.

1. Philosophy of science
Given the outstanding successes of empirical science, there is something rather puzzling to the lay enthusiast about the extent to which accounts of the methods of science and its forms of explanation lead to controversy and disagreement. Conceptual confusion appears to be the norm, not just confined to psychology and set theory as Wittgenstein (1953) has it.

Naïvely, one is led to expect that all scientific enterprises have something in common but efforts to determine those features have not led to consensus. Following Rescher (1977), I would like to point out one feature which does
appear to be an essential: science is self-corrective. One looks to the technological fruits of scientific investigation to bear testimony that today’s theories and methods are more powerful as tools for transforming man’s world than those of yesterday. For the moment, it is a moot point whether the applications of those tools are good for man and, in a very strong sense, bear rational justification. As noted below, the nature of rationality is what is being put into question.

Trivially, the self-corrective nature of science is to be expected. At the end of the day, “reality” is the final arbiter. Pragmatic, instrumental and operational accounts of the scientific method emphasise this. But science is more than an exploration and description of the given. Scientists also seek explanations. Not all are content with a “pure” technology or can achieve it. Concepts may be operationally defined but they are related together in a systematic way and understood as reflecting constraint or lawfulness found in reality. Thus, Einstein develops his account of relativity by rigorously applying operational concepts of length, mass and time in the light of what is known as fact (the constancy of the speed of light) and exhibits the necessity of the relation, $e = mc^2$ (Einstein, 1954).

Skinner’s “behaviour shaping” technology is couched in operational terms. Rauchlin (1970), amongst others, makes the underlying mechanism explicit (an adaptive system that employs negative feedback to maintain or achieve desired states).

The derivations, structures and justifications of scientific explanations (theories) are what lack an agreed account. As such, the key questions addressed by philosophers of science are epistemological. As Suppe notes, the history of epistemology is largely coextensive with the history of the philosophy of science (Suppe, 1977). What are sought are rational accounts of rationality.

Suppe gives a picture of contemporary philosophy of science at the crossroads. He contends that the issues and controversies addressed by a majority of thinkers during the first half of this century led to a consensus of sorts, one which no single individual endorsed in its entirety but which held sway and not only dominated philosophy but also constrained scientists themselves, especially those who were concerned to establish firm foundations for the emerging sciences, psychology, biology, sociology. He refers to this consensus as “the received view” and traces its recent history, from the mechanistic, materialistic positivism of the late nineteenth century to the sophisticated logical positivism of the “Vienna Circle” (Schlick, Carnap and others).

The thinkers in question wished to make clear the epistemic status of scientific theories. According to Suppe, the “received view” states that theories are “axiomatic calculi given partial observational interpretation by means of correspondence rules”. A striking example of how this view of the nature of scientific theories influenced psychology is to be found in the work of Clark Hull (Hull, 1952). Koch (1959) gives an elegant account of the rise and fall of Hull’s research programme and includes a fascinating autobiographical article by B.F. Skinner telling how he finally abandoned Hullian style theorising in favour of his now famous “atheoretical” approach to the study of behaviour.
Criticisms of the “received view” have focused on several aspects: questioning the need for axiomatisation, the distinction between theory and observation (and the underlying distinction between analytic and synthetic statements) and calling for a much richer account of how science is in fact practised.

One influential approach, exemplified by Kuhn, Feyerabend and Hanson, has adopted a sociological perspective, characterising scientific disciplines as social institutions each with its own weltanschauung or world view. The major criticism of this approach is that, in its extreme form, it fails to account for the objectivity and rationality of science. In general, critics have demanded a tighter, more coherent account of such phenomena as “revolutions in sciences” and “paradigm shifts” (Kuhn, circa 1962).

Suppe distinguishes an alternative approach which shares many of the strengths of the weltanschauung analysis (e.g. wishing to give an account of scientific praxis) but one which eschews “sociological analysis” in favour of “metaphysical and epistemological realism”, in essence, an approach which accepts that scientists are dealing with a common world, are in some sense producing “true knowledge” and are doing so “rationally”.

He refers to this alternative as the “semantic” approach because of its central thesis that theories have a non-linguistic content: a mathematical structure, icon or model which is given an interpretation. Such a structure is a syntactic (analytic) entity, but is part of a theory only insofar as it is given a semantic interpretation (which requires synthetic propositions). To anticipate, the cybernetician, Frank George, says tersely: a model can be anything: a piece of apparatus or marks on paper; “a theory is a model together with its interpretation” (George, 1961).

Many writers have contributed in this context. Hesse (1963) emphasises the role of analogy and metaphor in the construction of scientific theories. The cybernetician, Gordon Pask (Pask, circa 1963), develops her argument, presenting a model of analogical thinking itself, as a species of control process. Patrick Suppes (1962) has given an elegant account of scientific praxis which argues that the scientist operates with a hierarchy of theories, including the theory of the experiment, the theory of the design, the theory of the data and “ceteris paribus”. Rapoport (1958) presents a taxonomy of theory types. Many other writers have written on the theme of types of theory and types of model. Pask (circa 1973) classifies models applied in the social sciences. Foss (1966) distinguishes several types of explanation sought in psychology.

Suppe applauds Shapere’s approach (Shapere, 1977) and does so for several reasons. In particular, Shapere stresses that a scientific domain itself generates problems that are particular to it. Accounts of science must distinguish and characterise scientific domains. Shapere also stresses the open-ended generative nature of scientific praxis. Not only are new problems addressed but there is continual refinement in method and, he stresses, modes of reasoning. He states the latter as an aphorism “we learn how we learn as we learn”.

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Suppe concludes his commentary by focusing on the perennial problem of scepticism, which stands as a stumbling-block for the realism he has in mind. In particular, the proposition that “knowledge is justified true belief”, accepted by a realist, is attacked by the sceptic, who asks, “How can one ever know that one’s claim to know is true?” Descartes and Kant put forward sceptical arguments in terms of the corruptibility of the senses. Hume cast doubts on the process of induction which have never been satisfactorily answered, despite many attempts to construct a logic of induction from J.S. Mill onwards. As Rescher (see below) puts it, induction is itself justified inductively.

Suppe accepts the force of the criticisms and is prepared to reject the need for an absolute criterion of what true knowledge is but in its place he wishes to make a clear distinction between the “role of evidence in the rational evaluation and defence of knowledge claims from the role evidence plays in obtaining knowledge”.

In the evaluation and defence of knowledge claims, one argues for the truth of a belief and presents evidence as part of the justification. Thus “what qualifies a knowledge claim as acceptable will depend on both available data and patterns of reasoning . . . there is an open-ended variety of the latter” (Suppe, 1977). In obtaining knowledge, the evidence must guarantee its truth. Justification of a knowledge claim necessarily falls short of this standard.

I am probably not alone in finding Suppe’s discussion in this, the final part of his essay, somewhat obscure. I can see he insists on maintaining a realist’s stance vis-à-vis the “objectivity” of science and is trying to do so in the face of sceptical arguments concerning the possibility of knowledge that is known to be true. I think the issue is simplified if one accepts that to be a scientist is to accept the belief that there is an objective reality that can be investigated scientifically. This makes science a publicly agreed and publicly constructed affair. For C.S. Pierce, absolute truth is then that which science approaches asymptotically given infinite time (Pierce, 1972).

As noted in the introduction a further distinction is possible, that between meaning and truth. Scientific rationality generates meanings, propositional knowledge, in the form of its theories, the “truth” of which (as discussed in the next section) may be assessed publicly, “objectively” both for their logical coherence – as in the tautologies and formal “truths” of logic and mathematics – and their pragmatic effectiveness. In contrast, there is a truth that is “entered into” and experienced as a Gestalt of affect and cognition. This truth is private, subjective and transcendental. The experience, as evidence, contains its own guarantee.

2. The “conceptual idealism” and “methodological pragmatism” of Nicholas Rescher
In a series of books (Rescher, 1973a, 1973b, 1977), Nicholas Rescher has attempted a systematic solution to the classic problems of ethics and epistemology, drawing much of his inspiration from the nineteenth century philosophies, pragmatism and utilitarianism. As I note in my concluding
comments, his programme founders on his making an unwarranted distinction between “welfare” (the good) and “knowledge” (the true). My chief concern here is with his epistemology. He is concerned to reveal the form of scientific praxis as a rational, self-corrective procedure, whose great power resides in the continual refinement of its methodology, including what Rescher refers to as cognitive methodology (logic, mathematics, philosophy itself). Whilst acknowledging that the final arbiter of the effectiveness of a method to produce or validate knowledge lies in praxis (hence, his pragmatism), he also wishes to acknowledge the role of conceptual ideals (a priori). In essence, and with due acknowledgement, he argues for a constructivist understanding of logico – mathematical reasoning, as sought by Piaget. As a philosopher of science, rather than a child psychologist, he is particularly interested in, for example, the codification of methods (logics) from their presystematic practice.

By distinguishing the roles of praxis and ideals, Rescher attains an epistemology which, unlike other “evolutionary epistemologies” (see Kuhn, Popper, Toulmin, Quine), which focus on the Darwinian survival of a theory, has a role for survival by fitness (applied ultimately to methods) and survival by rational production and justification (the employment of cognitive methodologies that, for example, seek coherence, parsimony, completeness).

Rescher subtitled his work “a systems-theoretic approach to the theory of knowledge”. This reflects both his interest in the coherence properties of conceptual systems (scientific theses) and in the self-corrective nature of science as a process. Cognitive methodologies evolve to serve a regulative (as distinct from a constitutive) function. They serve as criteria for what is to be considered true knowledge whilst themselves being subject to progressive, evolutionary refinement. Circularity is implied but is “virtuous” rather than “vicious”, i.e., whilst the circle has the form shown in Figure 1.

It avoids the infinite regress of the sceptic (noted above: “what are the criteria for the criteria . . . ?” known classically as diallelus, the wheel) by recognising that the circle is a process in time; the already mentioned self-corrective nature of science is explained as a cybernetic circuit with feedback.

Rescher’s contribution is the recognition of the need for two cycles. The first cycle concerns the pragmatic evaluation of the effectiveness of methods (the operation of a “reality principle”) (Figure 2).

The second cycle concerns the semantic and syntactic evaluation of the coherence of cognition (Figure 3).

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**Figure 1.**
Circularity

**Figure 2.**
First cycle
Before putting the two cycles together, it is worth noting that the second cycle accounts for the generation and proliferation of grand theories that are satisfying in their conceptual richness and internal coherence but, nevertheless, have little to support their claims of offering guidance in how to deal with reality (astrology, for example).

The two circles are fitted together by recognising that the “putative truths” involve both methodological (regulative) and theoretical (constitutive) truths (Figure 4).

At any particular stage, a sequence of operations is followed. One asks, for example, “can I logically order (systematise) my knowledge?” and may question the truth status of the knowledge as a result. This may lead to further refinements in empirical investigation.

At another stage, one asks, “Given what is presumed true about the world, does my formal apparatus for the making of inferences adequately reflect that order?” and may question the universality of one’s logic as a result.

By revealing the process of epistemic validation in science, Rescher has given due acknowledgement to the primacy of affect, praxis. At the same time, he has shown how cognitive methodology may evolve such that a logic and rationale can guide praxis. Although the outcome of praxis is the final arbiter of the effectiveness of those methodologies, the methodologies (cognition, metacognition) are such that they provide not only an apparatus for substantiating theses about the world but also an apparatus for their own rational evolution and refinement. The logic of scientific discovery thus pulls itself up by its own bootstraps. There remains a real sense in which logic (cognition) has primacy. Piaget (1956) captures the complementarity of affect (praxis) and cognition as follows: “Without a mathematical or logical apparatus there is no direct ‘reading’ of facts, because this apparatus is a prerequisite. Such an apparatus is derived from experience, the abstraction being taken from the action performed upon the object and not from the object itself.”
With this account of the evolution of science from its presystematic beginnings, one can see an inevitability underlying the emergence of cybernetics with its telos firmly rooted in the need to understand cognition. In this respect, it echoes Hegel. Unlike Hegel, though, an awareness of its own origins does not constitute an "end to philosophy". Instead, there is the recognition that man’s attempts to control the uncontrollable are endless, that, as Spencer-Brown (1969) puts it, “the universe will always expand to escape our telescopes.”

3. Cybernetics and development

3.1 Systems theory and cybernetics

Historically, systems theory and cybernetics developed in different contexts. Wiener (1948) first distinguished cybernetics as a new discipline, the science of control and communication in the animal and the machine, following the successes of mathematicians, engineers and biologists, anthropologists, psychologists and others who, in interdisciplinary exchanges, shed light on the nature of purposive, goal-seeking behaviour in natural and man-made complex systems. The phenomenon of feedback, involving a circularity of causation, was recognised as a universal feature of such systems, found in the workings of the humble thermostat and in the complex homeostatic processes that maintain the fabric and stability of biological and social systems (see von Foerster et al., 1953).

A general theory of systems was independently proposed by Von Bertalanffy (1950). As a biologist, Von Bertalanffy and others (notably Weiss) emphasised the "holistic" nature of the organisation of living systems, captured in the Aristotelian aphorism that “the whole is more than the sum of its parts”. Von Bertalanffy is responsible for the distinction between “open” and “closed” systems. In his original definition, the distinction made was in terms of the exchange of matter and energy between the system and its environment. An open system persists as an organisation whilst engaging in such exchanges. A closed system is adiabatically sealed from its environment. In its isolation, it is subject to the second law of thermodynamics: over time its order (organisation) decreases and its disorder (entropy) increases. According to this definition, a candle flame and a living organism are open systems.

The contribution of cybernetics was to make a clear distinction between matter and energy, on the one hand, and information and control, on the other. A candle flame and a living organism are indeed both energetically open systems but the latter has the additional property of defining its own boundaries. It is self-organising. From the outset, key thinkers recognised that, underlying the relative differences in emphasis, there is a fundamental unity of interest between cybernetics and systems theory. As Ashby (1956) phrased it, both are primarily concerned with systems that are “open to energy and closed to information and control”. An “informationally closed” system adapts to environmental disturbances. In doing so, it can be said to become more informed of its environment. From the perspective of an external observer, certain of its matter-energy exchanges may be seen as “carriers of information”.

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The system may be structurally coupled with other systems. In this restricted sense, the system, as part of a larger system, is informationally open. However, an external observer’s distinguishing and measuring of such “information exchanges” are system relative. As Konorski (1962) puts it, “information cannot be separated from its utilisation”. What remains intrinsic to the system, despite changes due to adaptation, learning, maturation and evolution, is the basic circularity of its organisation: it consists of processes that produce structures that embody those processes.

The concept of “organisational closure” is discussed further, below. For the moment, it is sufficient to note that, in such a system, the whole is indeed greater than the sum of its parts. A disturbance in a part of the system will necessarily affect all other parts of the system.

From this brief discussion, it should be clear that “systems theory” and “cybernetics” may be used interchangeably as labels for the emerging science that studies the organisation of complex systems. I have a preference for the term cybernetics because of its historic connection with the need to understand cognition and purpose. Ashby (1956), for example, is always at pains to make clear the role played by the observer’s own purposes and interests in determining how a system is to be defined, described and explained. In the next section, I look more closely at the cybernetician’s concept of explanation.

3.2 Cybernetic explanation

Craik (claimed as a founder of cybernetic thought) considered that the brain functions so as to model reality and that such modelling constitutes the content of scientific explanation (Craik, 1943). With this insight, there has been a general liberation in thinking about what form a scientific explanation should take. The semantic approach, in its criticisms of the “received view” of the structure of scientific theories, is in general accord with Craik’s thesis.

Advocates of “the received view” tend also to be “reductionist”: phenomena are explained when they are accounted for by appeal to atomic units or processes occurring at a “lower” or more fundamental level, whose lawful interactions produce the phenomena in question (see Cohen and Nagel, 1934). Thus chemical processes are “explained” by reference to the physical laws governing the interactions of atoms and molecules. Attempts are made to “explain” biological phenomena in terms of chemical processes. Psychological phenomena are “explained” by reference to “underlying” physiological processes and so on.

Cyberneticians rightly note that this is but one form of explanation, that which has been particularly fruitful in the physical sciences. They insist that other domains may be tackled best with different forms of explanation: ones which stress systemic properties and, by implication, the evolution and development of self-organising systems. Indeed, a generalised methodology of “cybernetic modelling” has evolved (Pask, circa 1961; Klir and Valach, 1967).

The distinction between forms of explanation has emerged in a variety of contexts. Many philosophers with interests in education distinguish “forms of knowledge”, constitutive of a particular domain or field of enquiry (Hirst, 1974;
Schwab, 1964). With respect to scientific enquiry, Shapere (1977) distinguishes two major categories of explanatory theory: the “compositional” and the “evolutionary”. As noted above, a major impetus to the growth of systems theory came from biology (Weiss, Von Bertalanffy), where problems with respect to explanations of organismic functioning, evolution and development can be traced back to Aristotle (Hindley, 1980; Koestler and Smythies, circa 1969).

Reese and Overton (1970) make a distinction between “mechanistic” and “organismic” explanations of development. Their discussion has generated much debate, particularly amongst psychologists and biologists concerned with child development. In the remainder of this section, employing the cybernetician’s concept of explanation, I try to clarify the issues involved.

Reese and Overton’s distinction corresponds essentially to Shapere’s distinction between “compositional” and “evolutionary” explanations. As summarised by Lerner (circa 1976), mechanistic explanation is reductionist (as described above), emphasising quantitative change, continuity and “additive effects”. In contrast, “organismic” explanation is “epigenetic” (cf. Waddington, 1975), emphasising qualitative change, discontinuity and emergence and “multiplicative” and “interactive” effects. Many writers have employed this distinction as a useful way of classifying different approaches in psychology and biology (e.g. Looft, circa 1973; and Salkind, 1981). Some (e.g. Berger, 1977) consider the two forms of explanation to be necessarily distinct. Others have sought a rapprochement. Urban (1978) and Sameroff (1982) suggest the answer lies in the application of systems theory but neither does little more than give an elementary review of system theoretic concepts. They cannot be said to grasp the nettle. In their hands “systems theory” is no more than a more refined statement of what is meant by “organismic”. Lest I appear to be too harsh, I shall let Urban speak for himself:

Efforts to explicate developmental processes which characterise the human person have faltered due to ambiguities in the conceptual models which have come to be employed. The use of a systems perspective is advocated as a means of remedy. Such a view permits useful distinctions to be drawn between the phenomena of change, and a subset of those changes defined as developmental. Development is represented in terms of systems transformation, and developmental processes as successive transitional states. An integrative view of the human is made possible by a model of generally distinct subsystems, interrelated by coupling mechanisms, both laterally and vertically organised, acting both concomitantly and sequentially in relation to the passage of time . . . Special emphasis is placed upon its (the systems perspective’s) capabilities for serving a synthetic function at the metamodel level.

One looks in vain for a clear specification of this metamodel or, indeed, any model in his account. Sameroff (1982) gives a reasonably clear and concise summary of the origins and intent of “systems thinking”. With respect to the problem of development and with due acknowledgement to Riegel’s (1976) views, he argues for a rapprochement of “mechanistic” and “organismic” explanation by “dialectic synthesis”.

I quote: “Dialectics considers development to be motivated by internal contradictions in all things . . . the internal contradictions in all systems is based on the fact that they are at the same time parts and wholes; at once, they are of
someone else’s hierarchy while containing their own’s.” As Sameroff notes, this aspect of complex systems has been developed at length by Koestler (circa 1967). Unfortunately, apart from applying the concept descriptively, as a metaphor, neither writer supplies an explanatory model.

The classical referent for the term “dialectic” is a conversation. Hegel, Marx and Engels apply the term to natural processes of change and evolution. For Engels, the “laws of dialectics” are metaphysical a priori to which reality must conform (Engels, 1940). As such, the “laws” are descriptive and prescriptive, not explanatory. For example, the law of “change of quantity to quality” states that, with an increase in the quantity of an attribute, a qualitatively different attribute will emerge. Engels cites the boiling of water as an example. Increase in temperature leads to the qualitative change of water to steam. In like manner, system theorists refer to the emergence of qualitatively new properties of systems whose complexity increases. While many theorists are content to point to the phenomena, stressing that the classical concepts of mechanism fail to account for such developmental and evolutionary changes, others have looked for explication.

The thrust of cybernetic thinking has been to look for a complete reappraisal of the issues wherever a scientific discipline has generated opposing schools of thought or explanatory paradigms. The syntheses sought are indeed dialectic but strictly in the sense that they refer ultimately to the cognition and conversation of scientific observers. The content of the conversation between observers is a relation, a system (in extreme, a “black box”). By manipulating the system and comparing models (marks on paper, voice patterns), the observers reach agreement and understanding. At the heart of cybernetic explanation, then, is a model, a tool, an artefact (cf. Pask, circa 1961; Waddington, 1977).

In the next section, I briefly survey some efforts at the cybernetic modelling of processes of development.

With respect to the issue of whether the models are “mechanistic” or “organismic”, the preliminary cybernetic analysis runs as follows: the demand for a mechanistic, reductionist explanation is a cognitive methodology: as such, the concept of mechanism itself can be made subject to question and explication. In classical science it appears as a metaphysical a priori, in the guise of causality or the principle of the uniformity of nature. The a priori nature of mechanistic explanation is logical not one that renders in nature. It stems from the needs of scientists who would articulate and share an account of how the world works. As Rescher makes clear, reality itself undermines the legislative forces of shared methodological and metaphysical presumptions. These comments are intended as tools for evaporating “pseudo-problems” (Wittgenstein, 1953). Whilst a working scientist has an unquestioned bias towards certain sorts of explanation as being the only legitimate ones, he is cut off from the “reality principle”. Whilst within a discipline one can discern distinct schools, one has clear evidence that the discipline is “conceptually confused”. 
The confusion in this instance is not helped by poor scholarship. The opposition between “mechanistic” and “organismic” explanation grew out of the earlier dispute between “mechanists” and “vitalists”. The former drew their inspiration from Newtonian physics and thus had a limited reductionist, atomistic (Shapere’s “compositional”) concept of mechanism and “mechanistic” explanation. The latter recognised the need for a different kind of explanation to account for biological phenomena and conceptualised a “vital force” as the missing ingredient. Their programme collapsed following progressive successes in biochemistry, notably the synthesis of organic compounds in the laboratory.

By the 1920s, a different approach that contrasted itself with mechanistic reductionism had arisen. This was “organismic biology”. One of the first to employ this label was Von Bertalanffy who advocated “the system theory of the organism” (see Von Bertalanffy, 1972, for his account of those early years).

As already noted, by the 1950s, Von Bertalanffy was advocating a fullblooded general theory of systems (not just for biology). It seems ironic that in the 1970s, the general theory should be advocated as a novel approach to the particular issues that led to its development.

In the intervening decades, two things have happened:

1. there has been a clearer statement of what a system is;
2. there has evolved a more profound understanding of what a mechanism is, thanks to the cybernetic concepts of feedback, information, control and circular causality.

It is now clearly recognised that there are levels of system, levels of lawfulness and levels of explanation. In particular, reductionist explanation is appropriate and useful in that higher level systems (e.g. the biological) necessarily abide by the laws of the lower level systems (the physical and chemical). In addition, each new level introduces its own laws, which are to be understood in terms applicable at that level (e.g. the “laws” of open systems).

Perhaps one of the most exciting developments has been the work focusing on system emergence. As Prigogine (1971) puts it, “the concept of stability reconciles the unity of laws with the existence of well-defined levels of description”. His major contribution has been to show how thermodynamic instability in chemical systems may lead to the emergence of “coherent macroscopic space-time organisations” that exhibit their own, systemic, stability. From this perspective, biological structures are seen to be “open chemical systems working beyond the instability of the thermo-dynamical branch” (1971, see also section 3.4).

Given that higher level systems are legitimate objects to be studied in their own right, how is this to be done? This is where the more general cybernetic concepts of mechanism and explanation by modelling enter the picture. As Ashby (1956) puts it, cybernetics studies “all possible machines”.

Grene (1971) is one of the few writers I know who clearly distinguishes between “mechanistic” explanation as sought by reductionists and
“mechanistic” explanation as provided by cybernetics and systems theory. Following Harre’s (1970) discussion of the heuristic role of models (icons) in scientific theories, she states, “We are entirely at liberty to draw our models whence we please: why not from cybernetics and systems theory if from such sources we acquire plausible suggestions for a mechanism which, if correctly guessed at, would in fact ‘produce the effects we wish to see’?”

To define living systems, with Longuet-Higgins, as machines capable of improving their own programs, may sound to ‘organismic’ biologists like one more reductionist slogan. Yet it says in effect, “look to engineering – to blue-prints and operational principles – not to chemistry and physics – for the sources of your theoretical models”. Holland’s model of adaptation, discussed in the next section, is just such a “blueprint” for “machines capable of improving their own programs”.

3.3 The development of cognition
Ross Ashby (1956) was one of the first to clearly see that evolution is a necessary property of any complex, dynamical system. Given any constraint (regularity or “law of nature”) that holds uniformly in the universe of which the system is a part, the system will evolve so as to be informed of (adapted to) that constraint. In this sense, all development is cognitive development.

Rescher, as discussed earlier, has given an account of the evolution of scientific praxis. Piaget (amongst others) has offered an account of the ontogenesis of human cognition. Both writers argue for a constitutive growth of logical forms (in the guise of cognitive methodologies and cognitive structures).

Rescher is content to begin his account with the “presystematic” logic of enquiry, in essence, trial and error, whose original justification was entirely pragmatic, seen, for example, in the behaviour of an amoeba. Piaget begins his account with the fact of self-regulation. I quote: “In general, if we are to account for the biological roots of these structures and the fact that they become necessary, we must think in terms neither of the exclusive action of the environment nor of an innate preformation but of self-regulations, functioning in circuits and having an intrinsic tendency towards equilibrium” (Piaget, 1972).

Piaget, on many occasions, acknowledges that his underlying model is cybernetic in character. (See Boden, 1979, Chapter 7, for an extended discussion of Piaget’s affiliations with cybernetics.) Other than acknowledge the existence of self-regulative properties as a necessary precursor to cognitive development, he gives no satisfactory account of them. Indeed, so often has his concept of “equilibration” been criticised that Boden (1979) argues that it would be better if he cast his theory in computational, information processing form, where procedures may be spelled out in explicit detail. Although there is merit in such a recommendation, Boden confuses the issue by not only making a distinction between the “dynamics” of systems (i.e. their self-organising properties) and the “structure” of systems (their forms of computation) but argues that the study of the latter (as evidenced by research in Artificial Intelligence (see Boden, 1977)) is
the “new” cybernetics that has superseded the “classic” cybernetics. Whilst it is true historically that there was a shift in emphasis, it is not true that the older problems and approaches have been finally resolved or found wanting. Certainly, the former is not the case. Implicit in Boden’s distinction is exactly the distinction one seeks to get to grips with: what sort of entity is it whose properties make it self-organising and lead it to evolve sophisticated cognitive methodologies for problem solving, pattern recognition, language comprehension and the like?

Attempts to clarify and answer these questions have taken many forms.

Both Ashby (1956) and Schroedinger (1944) have characterised living systems as “pockets of negentropy”, as local violations of the second law of thermodynamics. As such, living systems can be likened to the eddies in a river that temporarily appear to reverse its flow. As the sun’s energy pours into the “biosphere” of our planet, the constituent matter is actively moved through complex processes. When viewed as a whole, the ecosystem already shows to the observer two characteristics accepted by systems theorists as defining attributes of a self-organising system: its tendency to conserve itself through cyclic processes (stability) and its tendency to transcend itself through change and evolution.

At the heart of all systems classed as living are the large, highly stable molecules that, in an appropriate environment of substrates, are self-replicating.

The crucial moment in the evolution of life appears to have been the occasion when the first replicating molecules literally closed themselves off from their surrounds by acquiring the first primitive cell walls, permeable to material and energetic exchange but impermeable to change that would destroy their organisation.

Dawkins (1976) and Monod (circa 1972) give eloquent accounts of these qualitative changes in the evolution of living systems. How did this “organisational closure” first occur? A plausible model, in the form of a computer simulation, has been proposed by Varela et al. (1974). As Maturana (circa 1970) has stressed, the one universal characteristic of the organisation of the living system is its circularity: processes produce structures that embody the processes. The model consists of an initially unstructured set of processes involving enzymes and substrates, where the effect of the enzyme is to polymerise the substrates. In relatively simple simulations, they have shown how, in the right conditions of concentration, the structure produced encapsulates the enzyme cutting it off from further substrate. Occasional decay of bonds produces gaps through which more substrate may enter. Given that there is no intrinsic mystery to the workings of self-constructing, self-replicating entities (see also the abstract theories of self-reproducing automata, Von Neumann, 1966; Burks, 1970; Apter, 1966), one then has to account for adaptation and evolution. The occurrence of mutations of some sort in the context of natural selection is sufficient to account for the onset of evolution but a more robust model is required if one is to account for evolution...
as it has occurred on our planet. An early refinement was the development of
the process of sexual reproduction. Sexual reproduction has the strong
advantage that whilst preserving successful “genes” (the term is used in the
sense of Dawkins (1976), i.e. as an abstraction in the observer’s metalanguage
used to refer to both the plan or code that epigenetically gives rise to a
particular phenotypic structure or behaviour and to the material embodiment
of that code on a particular chromosome) it also generates variety of genotype
in the offspring.

A model of dynamic adaptation that is rich enough to account for the
evolution of cognitive structures has been proposed by Holland (1975).
Drawing his inspiration from the particular “variety generating” process of
sexual reproduction, Holland has distinguished a general class of “reproductive
adaptive plans”. Though based closely on what is known of genetics, his model
has general applications in economics, cognition, game theory and other
domains that require the successful control of (survival in) environments that
are themselves changing and evolving in non-linear, discontinuous, qualitative
ways.

The plans are pragmatically adaptive in that the structures that embody
them are reproduced as a function of their success or “fitness”. Many other
models of adaptive, evolutionary processes employ some sort of rule that
reproduces “successful” structures (plans, operators, schemata). Several are
reviewed in Apter (1966). Pringle’s (1951) is one of the earliest statements that
views learning as an evolutionary process. Pask’s (see Pask, 1975a) early
models of learning processes are attempts to simulate the “symbolic evolution
of concepts”. Fogel et al. (1966) employed simulated evolutionary processes in
their approach to artificial intelligence.

Holland’s chief insight is to recognise that adaptation requires something
extra if an effective “bootstrapping” from trial and error is to take place. That
extra something is an internal to the system source of variety which renders
the structures into coherent, organised wholes. He models this internal to the
system variety generating mechanism on the dynamics of meiotic cell-division,
where the genetic plans, embodied on chromosomes, are subject to random
assortment, crossing-over and translocation. Holland recognises the universal
character of the processes. Figure 5 attempts to catch the kernel of his theorising.
As an illustration, consider “crossing-over”. In the context of meiosis, it refers to the exchange of genetic material between homologous chromosomes. To understand the force of Holland’s generalisation, consider the net effect of applying a crossing-over operator in the absence of environmental input. There will be a steady-state with respect to the probability of a particular structure occurring in a particular locus. Environmental input disturbs the equilibrium. Structures that are successful in dealing with the disturbance are reproduced at the expense of other structures. Hence, they are more likely to find themselves located in the vicinity of other successful structures. Now crossing-over has a conservative effect: the closer together two structures are, the less likely is it that they are separated. Their continual association enhances the probability of their joint application and of their joint success. A set of “coadapted” structures evolves. At the same time as conserving successful structures, the continued application of crossing-over also ensures that novel structures are made available for evaluation.

As Holland further notes, the operators that act on structures are themselves structures and may themselves be subject to the same processes of adaptation. This generalisation allows for the evolution of hierarchically organised sets of co-adapted structures.

Interpreted as a model for cognitive growth, the system is seen to endlessly elaborate its representation (in the form of its plans) of the external world and at the same time to render its own internal organisation more “logical” and coherent. The close parallels between Holland’s and Rescher’s models should now be apparent. Indeed, Suppe (1977) refers directly to Holland’s work as demonstrating the inadequacy of simple models for the “evolution of ideas” based on analogues to mutation and survival by fitness as deployed, for example, by Toulmin (1971). Rescher refers to these approaches to evolutionary epistemology as “thesis pragmatism” to distinguish them from his own “conceptual idealism and methodological pragmatism”.

### 3.4 Mechanism, structure and morphogenesis

As noted in the last section, Holland’s model of “robust” adaptation has many applications. It can serve as a useful underpinning to accounts of cognitive growth and learning. Holland himself offers an interpretation of Hebb’s (1949) theory of neural organisation as an illustration. In the domain of child development, perhaps Fischer’s (1980) theory of skill acquisition and integration is the one most readily translatable into Holland’s framework.

As noted by Suppe, Holland’s model serves also as a useful framework for explanations of cultural evolution. Rather than pursue these ideas further, in this section I shall make mention of other issues and approaches in order to render my overall account of cybernetic explanation and development more complete. In the final section, there is a return to philosophy and the philosophy of science, where, as tersely as I can, I draw some general conclusions that, I hope, places the study of child development in its larger context.
In an earlier section, the question “what is mechanism?” was raised. Insofar as mechanistic explanation is atomistic and reductionist it is essentially Newtonian in character. Modern physics, in the form of quantum mechanics, has long ago abandoned the Newtonian view and in the hands of Heisenberg, Bohr, Schroedinger and others has arrived at a radically different view of the ultimate nature of the universe and of reality. Depending on the perspective of the observer, the “substance” of which the world is made appears as process or particle. The so-called “paradoxes” of quantum theory have led some radical thinkers to question the fundamental metaphysical a prioris which govern scientific praxis. Various forms of “acausal interconnectedness” have been discussed (see Capra, 1975). In a later book (Capra, 1982), Capra adds to his account the concepts of systems thinking and argues for the need for greater “intuitive ecological awareness” if man is to avoid doing irreversible damage to his environment. According to Capra’s synthesis the whole cosmos is organismically one and the observer is intrinsically part of that one. Similar accounts and critiques of Western thought are to be found in many places, e.g. Whitehead (1929), Huxley (1964) and Pirsig (1974).

From the perspective of monistic spirituality, reason and scientific praxis are seen as tools, whose application is best guided by “intuitive ecological awareness” (cf. Pirsig’s concept of “Quality”).

From this perspective, mechanistic explanation is one form of tool. As such, its scope and usefulness can be demarcated. Variants can be generated, which are not legislated out of court until their powers to predict and explain have been explored. That the world has evolved a proliferating variety of forms is accepted. “Reductionist” explanations are not sought as ends in themselves. Rather, models and metaphors are deployed that aid prediction and control and that render concepts and theories coherent.

Recent work of this kind has focused on the problem of structure and morphogenesis. Thom (1973) and his followers have developed a mathematical theory of structural change (so called “catastrophe theory”). In related work, Abraham (1976) is developing a science of “macrodynamics”. Prigogine (1980) has instituted a study of “stabilities in fluctuations”. In essence all are addressing themselves to the problem of describing and detailing the workings of Engels’ “laws of dialectics”. Much of the work is mathematical and is revealing the underlying forms to which nature conforms.

Thom, for example, has extended the classic mathematical concept of a “singularity”. This problem exercised the mind of the great nineteenth century logician, George Boole, throughout his life. I offer a simple example, taken from his writings, of the “law of change of quantity to quality” at work.

Take an arbitrary circle as a starting point and draw smaller circles of fixed diameter whose centres all lie on the perimeter of the first circle (Figure 6). As the number of smaller circles approaches infinity, a new form emerges (Figures 7 and 8).

There are now two “new circles”, each concentric with the first circle.
Prigogine’s contribution is to recognise the paradoxical state of affairs expressed in the aphorism: “a system maximises its ability to respond effectively to disturbance if it is maintained close to states of instability”. Living systems that are active and irritable are examples of such. One recalls Holland’s thought concerning the need for a “robust” adaptive system to have its own inherent source of variety (instability). The inadequacy of classical mechanical concepts to characterise self-organising systems was first elegantly stated by von Foerster (1960). By definition, the rate of change of redundancy (organisation) in such a system is always positive. A description of its behaviour with respect to a “state space” will eventually prove inadequate: the observer is obliged to update his frame of reference.

Prigogine’s major work is on system emergence (noted in section 3.2) and appears to have far-reaching implications. As I understand it, he has achieved a new synthesis of mechanics and thermodynamics. In the domain of quantum mechanics, this has entailed the introduction of a “local time” operator into the Schrödinger wave equation. Time proper emerges as the average for an ensemble. In this formulation of physical reality, “becoming” (change and
development) has an a priori status with respect to “being” (the stability of existing entities) and time is irreversible; in previous formulations, “time” has served as a parameter, whose sign may be changed, from + to −, without formal effect on the physics systems so modelled.

One powerful approach to the modelling of complex systems is computer simulation (see, for example, Zeigler, 1976) but as Pask, in particular, has stressed (see Pask, 1975b) the property of organisational closure is omitted in such simulations. In an organisationally closed system, processes are intrinsically cyclic and self-productive. Subsystems may act autonomously and asynchronously. The closure property guarantees that, as necessary, structural coupling (qua “information transfer”) takes place rendering processes temporarily synchronised. As Pask puts it, in biological computers, the processes executed (the programs) are not independent of the hardware. The medium for computation is itself bound to conform to the demand to maintain organisational closure. The waking brain has “a need to learn” and is subject to boredom and fatigue.

This concept of concurrent processes that (at least from the observer’s perspective) act asynchronously and become synchronised through information transfer has been recognised by many as the fundamental problem of cybernetics. McCulloch coined the term “heterarchical” to describe their organisation. At a given moment in time, the observer may discern a hierarchical configuration of subsystems but by the “principle of the redundancy of potential command” (McCulloch, circa 1965), at the next instant a new configuration may arise. McCulloch took as the paradigm for such a system the reticular formation of the vertebrate nervous system, whose initially asynchronous units gather information from all parts of the organisation. Those units with the most relevant information take command and, as a synchronised whole, the organism is committed to a particular mode of behaviour (eating, fighting, sleeping and so on). A computer simulation is described in Kilmer et al. (1969).

This brief account of approaches to the study of the structure, functioning and development of complex systems is necessarily incomplete. One additional approach, which promises much, does deserve mention.

Pribram (1977) and others have explored models for memory and cognition that draw their inspiration from holography. In such models, every subsystem is informed of, contains, the whole. This concept is reminiscent of Leibnitzian monads but these monads are allowed to interact. For example, the genetic code can be seen as the “logos” of the organism. The harmonious cooperation of cells not cancerous is in a sense predetermined but, in the ongoing dynamic of growth and adaptation, there is the need to interact as environmental input is accommodated to and assimilated. Uncertainty engenders awareness which acts as the “reference beam” that, guided by the intent of the organism, reconstitutes, as a Gestalt, the required information. If I (the organism) wish to enhance the efficiency with which my fingers carry pen to paper, I place my
awareness there. The system of afferent, efferent and kinaesthetic signals that coordinate my moves is, for a moment, an object, a part, to be studied by the whole.

The physicist, David Bohm, (see Capra, 1975) applies the analogy of the hologram to the whole cosmos and refers to the “implicate order”, or underlying form, that holds the cosmos together as an organic whole. A perhaps more conservative view is to recognise the mathematical forms of Thom and others as revealing the necessary order. Such forms exhibit the possibilities for growth and evolution. Chance, then, determines the particular line of development taken until the stage is reached where living systems evolve which, conscious of their origins, bring rational purpose to bear on their problems of survival (cf. Eigen and Winkler, 1982).

4. Child development

Man’s technological conquests have given at least some men time and opportunity to reflect on man’s nature and origins. As in other fields of study, there has been an explosion of research concerned with the study of children, infants and babies.

A child is a system in a system affected by and affecting that system. As Mead (circa 1934) and others have stressed, the self is a social process: “holographically” each individual is more or less informed of the society of which she is a part.

Every contact leaves a trace. The responsibility carried by those who work with children is indeed awesome. “Only if our parents and teachers are pure, can our children be pure”, says Mary Boole (1972), the wife of George Boole, herself a mathematician, teacher and psychologist but, in the words of the title of one of Bruno Bettelheim’s books, “Love is not enough”; we also need rational understanding.

The family and the school are the great institutions that are our primary transmitters of culture. Whether one is concerned to preserve or enhance our cultural values, this is most effectively carried out if those with the essentially cybernetic tasks of managing education and child rearing are equipped with the necessary tools: adequate models for understanding the self-organising systems that are the child, its family, its school. The spread of system theoretic and cybernetic thinking throughout the humanities, social and biological sciences is thus to be welcomed. At their worst, the concepts are used esoterically and to mystify. At their best they do indeed serve as a “lingua franca” and bring real unity of understanding and purpose to diverse enterprises.

Pask has developed a general theory of “conversational processes” as a unifying paradigm for psychology and sociology. In a review of the impact of cybernetics on psychology (Pask, circa 1969), he criticises his contemporaries for purveying a “systemic monism” and stresses the need to maintain a distinction between “taciturn” systems (whether open or closed) and “language oriented” systems (whether open or closed).
The former, as objects of study, have their goals set or discovered by an observer. The latter set their own goals and are investigated by an observer who participates in a conversational exchange. Pask has gone on to specify a general methodological apparatus for the study of conversational processes (Pask, 1975b) and, in particular, has looked at the forms of discourse engaged in by scientists who reach agreement and understanding. This part of his work closely parallels that of Rescher, described earlier.

von Foerster, in a similar spirit, has distinguished a first and second order cybernetics (see von Foerster et al., 1974). First order study is of “observed systems”. Second order study is of “observing systems”, systems that, too, act as observers. These distinctions are summarised in Figure 9.

There is an extensive literature on the use of rules and reasons as explanatory concepts in the social sciences, which bears on Pask’s distinction.

Pask is arguing for a duality of types of model and types of explanation (not an ontological dualism à la Descartes). Rather, the types reflect the Aristotelian distinctions between material and efficient “causes” (pertinent to taciturn systems) and formal and final “causes” (pertinent to language oriented systems). In accounting for the observer, as well as his observation, one necessarily makes reference to all four “causes”. Whitehead (1929) is similarly Aristotelian in his analysis of an occasion of experience, which, irreducibly, requires reference to “passage”, “extension”, “idea” and “intention”, where passage (in time) and extension (in space) correspond to efficient and material causes and idea and intention correspond to formal and final causes.

Wittgenstein (1953) explores the concept of “following a rule” (an idea guides an intention). Winch (1958) uses his arguments to explore “the idea of a social science” and, with due reference to Weber’s concept of verstehen, concludes that explanation in social science (which requires the concepts of idea and intention) is distinct from explanation in natural science (for which concepts of passage and extension are sufficient). Peters (1958), in his discussion of the concept of motivation, comes to similar conclusions. Harré and Secord (1972) and Harré (1979), whose work is based largely on Hampshire’s (1966) discussion of thought and action, explicitly refer to “formal causes” as being a necessary part of explanations of social behaviour.

<table>
<thead>
<tr>
<th>First Order, “taciturn” systems</th>
<th>Energetically Open, Informationally Closed</th>
<th>Energetically Closed, Informationally Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. Biological organism as object of study</td>
<td>e.g. Study of automata as “black boxes”</td>
<td></td>
</tr>
<tr>
<td>Second order, “language oriented” systems</td>
<td>e.g. Client-therapist, teacher-learner interaction</td>
<td>e.g. Artificial intelligence or “expert system” that is integrated in conversational exchange</td>
</tr>
</tbody>
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Figure 9.
First- and second-order systems
With respect to development, one sees, successively, a need to refer to passage and extension (physico-chemical systems), intentions (biological systems that are purposive and self-organising) and ideas (cognitive structures). Von Demarus (1967) gives an elegant Whiteheadian/Aristotelian account of “mind” from a developmental, evolutionary perspective.

Pask’s point, then, is that, whilst an external observer may infer ideas and intentions, a participant observer may enquire after them directly. Pask’s originality lies in his recognition that a person’s ideas and intentions, as descriptions of processes, will tend to exhibit “organisational closure”. A “psychological individual” is a systemic unity distinct from a biological one; it is “a fuzzily self-replicating system of memories and concepts” (Pask, 1975b). As such, the concept of “psychological individuality” can be applied to social systems and institutions, such as families, as well as to persons. Here, Pask builds a very neat conceptual bridge between individual and social psychologies.

Pask further notes that, with respect to language oriented systems (psychological individuals), the observer may himself act as a participant in the conversational process or may stand outside it as an external observer. Whatever his role and perspective, he is obliged to distinguish between causal interaction and linguistic, provocative interaction. Pask has applied these distinctions to studies of learning and teaching. Their relevance to studies of child-development can be seen, for example, in studies of mother-infant interaction. An external observer may choose to view the interaction as the causal interconnectedness (structural coupling) of taciturn systems. A behaviourist does just this. Alternatively, he may choose to view the interaction as a conversation between participants as would, for example, a Piagetian observing a mother and child discuss rules concerning correct behaviour (see Pask, circa 1966, 1976). There is no right or wrong in adopting a particular perspective. In clinical practice, for example, the eclectic practitioner commonly holds both views in mind and sees no incompatibility or contradiction.

Pask’s contribution can be seen as a major attempt at conceptual clarification so as to build bridges between, on the one hand, those who advocate “behavioural engineering” and, on the other, “humanistic” psychologists and psychiatrists (Kelly, Laing, Bateson) who emphasise that they are concerned with the properties of cognition and communication of systems that are, like themselves, persons. The study of child development is thus seen as a fascinating meeting ground of fundamental conceptual issues. To what extent, for example, does a mother’s tendency to see and treat her child as a person create that child as a person? Newson and Newson (circa 1979) amongst others see this as a central concern for child psychology. What they appear to be proposing is a theory of affect that complements theories of cognition. Parent and child share occasions of mutual pleasure. The wise parent recognises the value of these occasions of intersubjective awareness and mutual positive regard. In such a moment, the child can most effectively
be given cognitive input. Lessons are well learned and well remembered. There in a complex flow of affect and information is the subtle “dance” of the dyad. In this sense, good parenting (and in general, good teaching) is, par excellence, a cybernetic art.

The more general relevance of systems theoretic concepts appears when one recalls that a property of a self-organising system is that one cannot affect a part without affecting the whole. Not only must the child be viewed holistically (a challenge in itself) but, since the child and parent are parts of larger wholes (families, schools, neighbourhoods), these, too, must be in view. No open system can be considered in isolation from its environment. Environments, too, are systems; cybernetically, to fully model or explain one child’s behaviour is to fully model or explain its environment (past, present and future). One artfully makes projections and extrapolations. For example, one recognises that how well one explains a death or an injury to a child will contribute to, if not fully determine, how that same child will do the same for its children when it is an adult. It is no accident that “good parenting” produces “good” parents; it is part of a “good” parent’s awareness of his or her responsibility that he or she, in raising a child, is raising a parent.

5. Concluding comments
As noted in section 2, Rescher’s writings address ethical and epistemological issues. His pragmatism is ultimately concerned with enhancing man’s “welfare”, doing good. Having through his epistemology, clarified the concept of scientific truth, he rightly distinguishes the “pursuit of pleasures” from the “pursuit of knowledge” and thus avoids the pitfalls of William James’ pragmatic theory of truth, criticised by Bernard Russell for equating “success” with “truth” (see Passmore, 1966).

However, this does leave a void between the good and the true. Monistic thinkers wish to bridge that void. In the introduction, I alluded to the distinction between meaning and truth. That distinction intended is that between the meanings arrived at in the rational pursuit of scientific knowledge and their contingent, relative “truths” and the “unsayable” truth felt and known by those who enter the “kingdom of heaven” which, Jesus assures us, “lies within”. There indeed, the good and the true are one.

Epilogue
From the perspective of the year 2000, my reading of the foregoing essay is that in developing its account of “cybernetic explanation” it argues for what in current modish terms would be referred to as an “evolutionary, constructivist epistemology”. In doing so, it distinguishes four notions of truth: truth by coherence, truth by correspondence or pragmatic effectiveness, transcendental truth approached asymptotically, and transcendental truth experienced directly.

The essay also presents a variety of cybernetic models of development, possible “machines”, including machines which construct accounts of their own
genesis. Necessarily, the essay also considers models of the cosmological processes of “development”, “becoming” and “unfolding”. For these latter, the observer is irrevocably a part of what he or she observes. She is ineluctably caught in a hermeneutic loop, where, as a “being in time”, she constructs concepts of “being” and “time”. This is where cybernetic explanation confronts the “ineffable”. But, though “explaining” has limits, we may still will and do: “Thy Kingdom come . . .”

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