Cybernetic Foundations for Psychology

Bernard Scott • Center for Sociocybernetics Research, Germany • bernces1/at/gmail.com

> Context • The field of psychology consists of many specialist domains of activity, which lack shared foundations. This means that the field as a whole lacks conceptual coherence. **> Problem** • The aim of the article is to show how second-order cybernetics can provide both foundations and a unifying conceptual framework for psychology. **> Method** • The field of psychology is overviewed. There is then a demonstration of how cybernetics can provide both foundations and a unifying conceptual framework. This entails defining some key cybernetics concepts and showing how they have already permeated the field, largely implicitly, and showing how, when made explicit, they can unify the field. **> Results** • I show how concepts from second-order cybernetics can unify "process" and "person" approaches within psychology and can also unify individual psychology and social psychology, a unification that also builds conceptual bridges with sociology. **> Implications** • The results are of value for bringing order to an otherwise inchoate field. They afford better communication between those working in the field, which is likely to give rise to new research questions and more effective ways of tackling them. **> Constructivist content** • Central to the article is a reliance on concepts taken from the constructivist perspective of second-order cybernetics. **> Key words** • **First-order cybernetics, second-order cybernetics, conceptual foundations, conceptual unification, system, self-organisation, control.**

"The confusion and barrenness of psychology is not to be explained by calling it a "young science"; its state is not comparable with that of physics, for instance, in its beginnings. (Rather with that of certain branches of mathematics. Set theory.) For in psychology there are experimental methods and conceptual confusion. (As in the other case, conceptual confusion and methods of proof.) The existence of the experimental method makes us think we have the means of solving the problems that trouble us; though problem and method pass one another by." (Wittgenstein 1953: 232)

Introduction

« 1 » From the 1950s onwards, concepts from cybernetics spread throughout psychology. In particular, they helped give birth to the domain of modern cognitive psychology. Models of "information processing" became ubiquitous and the research interests of cognitive psychologists increasingly overlapped with those of workers in artificial intelligence research, helping spawn the multidisciplinary domain of "cognitive science." Cybernetic concepts also permeated other domains within the broad field of psychology. However, with rare exceptions, the historical origins of the concepts were lost. Also lost was the intent of the early cyberneticians to look for interdisciplinary enrichment and transdisciplinary unity. In this article, I overview the field of psychology as it currently stands, with its many areas of research and application, which, to a large extent, exist as separate specialist domains of activity (for example, the several subdomains that make up biologically and behaviourally based psychology, cognitive psychology, social psychology, developmental psychology, abnormal psychology and the study of individual differences). I then demonstrate how cybernetics, when its contributions are made explicit, can provide both foundations and an overarching unifying conceptual framework for psychology. In order to do so, I make the distinction between first- and second-order cybernetics and briefly define some key cybernetic concepts, including "system," "self-organisation" and "control" (Scott 2011, 1996). I also make a broad-brushstroke distinction between "process" and "person" approaches within psychology. I go on to show how cybernetic concepts can unify these approaches. I also show how cybernetic concepts can unify individual psychology and social psychology, a unification that also builds useful conceptual bridges with psychology's sister discipline, sociology. I include reference to my personal experiences as a practitioner psychologist who encountered cybernetics at an early stage in his studies and who has found that cybernetics can indeed provide conceptually satisfying and practically useful foundations for psychology. It can reveal underlying similarities between problem situations and provide tools for modelling those situations. It can facilitate more effective communication between practitioners.

« 2 » The treatment is necessarily terse given constraints on the length of the article. The author may provide a book-length treatment in the future. In the meantime, it is hoped that the article will generate wider discussion of the issues raised. It should also be noted that cybernetics is an abstract discipline. I have not attempted to provide a comprehensive account of its many applications in psychology. There is a wealth of examples in standard texts, though not explicitly named as such. (See for example, Eysenck & Keane 2015).

The story of psychology

« 3 » Standard histories (for example, Miller 1962; Hunt 1993) tell us that psychology emerged from philosophy as a science in the late 19th century, a key moment being the founding, by Wilhelm Wundt, of the first laboratory dedicated to empirical studies of psychological phenomena. An emphasis on the scientific value of empirical data, rather

http://constructivist.info/11/3/601.scott

than armchair theorising, combined with the controversies over the validity of data derived from introspection, led to the rise of behaviourism as the dominant paradigm (or "school"), a dominance that lasted until well into the 1950s and early 1960s. Behaviourists aspired to make psychology an objective science. They abjured reference to consciousness and reference to "inner" experience and studied behaviour as objectively observable phenomena, using controlled experimental conditions that afforded replication of findings. For convenience, many studies were carried out using animals, such as rats and pigeons. The main research programme of behaviourists was focused on studying learning. At an extreme, explanations of how and why learning occurred were eschewed in favour of empirically derived "laws" that afforded predictions about when and where learning would occur – for example, under what circumstances a rat could be most effectively induced to learn how to navigate a maze or a pigeon's behaviour shaped so that it responded in predictable ways in response to particular stimuli.

« 4 » Competing paradigms included structuralism, functionalism, Gestalt psychology, depth psychologies (such as psychoanalysis) and humanistic psychology. In the 1960s, inspired by concepts from cybernetics, a new dominant paradigm arose: cognitive psychology. Cognitive psychology addressed issues to do with attention, perception, memory and problem solving, topics that had been addressed in earlier decades and that had amassed a wealth of empirical findings. What the "new" cognitive psychology contributed was new ways of talking about, and modelling, cognitive processes. The central analogy ran like this, "As programs are to computers, so thoughts are to brains." Models of cognitive processes were built that showed the flow of "information" around a cognitive system. Many such models consisted of static images of boxes and arrows. Others adopted a "computational" approach and were written as computer programs. Parallel work in computer science aimed to create "artificial intelligence" programs to solve problems, to serve as "expert systems," process images, interpret natural languages and acquire "knowledge." A new field became demarcated, "cognitive science," centred on the concept that both brains and computers are "physical symbol systems." This work following this paradigm continues today. I say more about these developments below.

« 5 » For psychology, a seminal text was the book *Plans and the Structure of Behaviour*, authored by George Miller, Eugene Galanter and Karl Pribram (1960). Not only does the book introduce key concepts relevant for the new approaches in cognitive psychology, it also gives an account of the origins of these concepts in the then emerging field of cybernetics. Other texts that highlighted the relevance of concepts from cybernetics for psychology were George (1960) and Pask (1961). As in other fields, as the years passed, researchers took from cybernetics those concepts they found useful for their special areas of interest, ignored or rejected others and very soon forgot their origins.

« 6 » In more recent decades, "cognitive neuroscience" and "physiological psychology" (or, taken together, "biological psychology") have come to the fore, largely due to the ability to map and manipulate activity in the nervous system and the major advances made in understanding these processes, anatomically and physiologically, down to the molecular level, where the interactions of the endocrine system, the nervous system and the immune system can be seen to form a systemic whole. Because of the systemic nature of this whole, in what follows I frequently refer to the "brain/body system" rather than refer to the brain as if the nervous system was all that is of interest.

« 7 » If one considers psychology as a whole field, one can see that over the years there has been a to-ing and fro-ing as paradigms have become more or less dominant or fashionable, with the major shifts having been brought about by the impact of concepts from cybernetics. Mainstream psychology continues to place great emphasis on empirical research. Associated theorising and model building tends to be specific to a domain or subdomain. Overall, there is still conceptual confusion and controversy over what psychology is about: what it should be aiming to achieve and how it should pursue those aims. At a metatheoretic level, there is now an explicit domain of "critical psychology" that questions the assumptions that underlie mainstream practice (see, for example, Sloan 2000). There is also a periodic (and less critical) attempt to examine the epistemological foundations of the several paradigms (see, for example, Chapman & Jones 1980; Leary 1990).

« 8 » To illustrate the unchanging face of psychology as a field consisting of a variety of topic areas and approaches, in Box 1, I list the contents of standard undergraduate text books: one from the 1960s (Sanford 1966) and two bestselling texts from the 2000s (Hayes 2000; Gross 2010). I, myself, was an undergraduate in the years 1964–1968 and taught undergraduate courses in psychology, on and off, between 1968 and 2000. I was thus a witness to the changes that occurred in those years. One topic not featured in Box 1 that was (and still is) commonly taught as part of undergraduate courses is organisational psychology.

« 9 » In anticipation of the next section, I wish to say a little more about the conceptual confusion that Wittgenstein above refers to. The crux of his critique is that we should look carefully at how we use words to talk about psychological events and processes, as a way of avoiding the ontologising of "mind" and "matter" (for "matter," one could also write "brain") as different kinds of fundamental "substances." This ontologising comes with the adoption of one of the particular metaphysical positions that underly the competing paradigms in psychology. In brief, both functionalism and structuralism employ dualistic parallelism (mental events are correlated with physiological processes); some dualists also advocate a Cartesian mind/brain interaction; mainstream behaviourism is monistically materialist and reductionist (talk of mental events is not permitted); "cognitivists" are ontologically monist, materialist reductionists in that they reduce the "mental" to the status of programs executed by a computer.

« 10 » In the unpublished essay "The relevance of Wittgenstein's philosophy of psychology to the psychological sciences"[1] Peter Hacker provides an extended discussion of Wittgenstein's position and its relevance for psychology. As discussed further below, cybernetics in its role of a metadiscipline and a transdiscipline engages in the kind of "philosophical ground clearing" that Wittgenstein (and Hacker) calls for.

1 | http://info.sjc.ox.ac.uk/scr/hacker/DownloadPapers.html

Understanding cybernetics and its contributions to psychology:The story of cybernetics

« 11 » I am not aware of any single text that gives a clear and inclusive account of the origins, early years and key later events concerning cybernetics. Here, I will give a very brief summary.[2]

« 12 » The story has several possible beginnings. One common starting point is the publication, in 1943, of the paper "Behavior, purpose and teleology" by Arturo Rosenblueth, Norbert Wiener and Juliann Bigelow and associated discussions that lead up to the Macy conferences on "feedback and circular causality in biological and social systems" held between 1946 and 1953. The paper proposed that the goal-seeking behaviour that could be built into mechanical systems and the goal-seeking observed in biological and psychological systems have a similar form: they are structured so that signals about achieved outcomes are "fed back" to modify inputs so that, in due course, a prescribed goal is achieved (a cup is picked up) or a desired state of affairs (the temperature of a room or of a living body) is maintained. This process is referred to as "circular causality." It was recognised at an early stage that many fields of study contain examples of these processes and that there was value in coming together in multidisciplinary fora to shed light on them, to learn from each other and to develop shared ways of talking about these phenomena. In 1948, Norbert Wiener, one of the participants, wrote a book that set out these ideas in a formal way that not only collected together many of the emerging shared conceptions but did so in a coherent way that not only facilitated interdisciplinary exchanges but also stood as a discipline in its own right: an abstract transdiscipline –

2| As further reading, I suggest Heims (1991), Glanville (2002), Pickering (2010), Scott (2002, 2004) and Müller & Müller (2007). I also recommend the 2006 biography of Norbert Wiener, written by Flo Conway and Jim Siegelman. One should also consult key texts of cybernetics' founders and early contributors: Wiener (1948), Ashby (1956), Pask (1961), Foerster, Mead & Teuber (1953), Bateson (1972).

Box 1: Contents of standard undergraduate text books

Contents listing for Sanford (1966)

Part One: Introduction 1. Knowing the human being. 2. Theories of people.
Part Two: Biological Foundations of Behaviour 3. The developing organism. 4. Biological basis for integrated behaviour.
Part Three: Methods in Psychology 5. Tests and measurements in psychology. 6. Experimental design and psychological statistics. 7. Intelligence.
Part Four: Segments of the Psychological Process 8. Motives. 9. Emotions. 10. Sensation. 11. Perception. 12. Basic processes of learning. 13. The management of learning. 14. Higher mental processes.
Part Five: Behaviour of the Whole Organism 15. Personality. 16. Adjusting. 17. Neurosis, psychosis and psychotherapy. 18. Social psychology.

Contents listing for Hayes (2000)

1. Perspectives in Psychology.
Section 1: Cognitive Psychology 2. Perception and Attention 3. Memory 4. Language and Literacy 5. Thinking and Representation.
Section 2: Individuality and Abnormality 6. Intelligence 7. Theories of Personality 8. The Medical Model of Abnormal Behaviour 9. Alternatives to the Medical Model.
Section 3: Physiological Psychology 10. Brain Development and Clinical Neuropsychology 11. Consciousness 12. Sensation and Parapsychology 13. Emotion and Motivation.
Section 4: Social Psychology 14. Self and Others 15. Understanding Others 16. Social Influence and Social Action 17. Attitudes, Prejudice, and Crowd Behaviour.
Section 5: Developmental Psychology 18. Learning and Skill Development 19. Cognitive Development and Social Awareness 20. Social Development 21. Lifespan Developmental Psychology.
Section 6: Comparative Psychology 22. Introducing Comparative Psychology 23. Animal Behaviour 24. Animal Communication 25. Methods and Ethics in Psychology.

Contents listing for Gross (2010)

The Nature and Scope of Psychology: What is this thing called psychology? Theoretical approaches to psychology. Psychology as a science.
The Biological Basis of Behaviour and Experience: The nervous system. Sensory processes. Parapsychology. States of consciousness and bodily rhythms. Substance dependence and abuse. Motivation. Emotion. Learning and conditioning. Application: health psychology.
Cognitive Psychology: Attention and performance. Pattern recognition. Perception: processes and theories. The development of perceptual abilities. Memory and forgetting. Language, thought and culture. Language acquisition. Problem-solving, decision-making and artificial intelligence. Application: cognition and the law.
Social Psychology: Social perception. Attribution. Attitudes and attitude change. Prejudice and discrimination. Conformity and group influence. Obedience. Interpersonal relationships. Aggression and antisocial behaviour. Altruism and prosocial behaviour. Application: the social psychology of sport.
Developmental Psychology: Early experience and social development. Development of the self-concept. Cognitive development. Moral development. Gender development. Adolescence. Adulthood. Old age. Application: exceptional development.
Individual Differences: Intelligence. Personality. Psychological abnormality: definitions and classification. Psychopathology. Treatments and therapies. Application: criminological psychology.
Issues and Debates: Bias in psychological theory and research. Ethical issues in psychology. Free will and determinism, and reductionism. Nature and nurture.

the study of "control and communication in the animal and the machine." Wiener called this new discipline "cybernetics." Following the book's publication, the Macy conference participants referred to their conferences as conferences on cybernetics, keeping "feedback and circular causality in biological and social systems" as the subtitle.

« 13 » As the subtitle emphasises, there was an interest in biological and social systems. The participants were interested not only in particular mechanisms, they also looked for the general forms to be found in the dynamics and organisation of complex systems (living systems, small groups and communities, cultures and societies): how they emerge and develop, how they maintain themselves as stable wholes, how they evolve and adapt in changing circumstances. The term "self-organising system" was adopted by many as a central topic for discussion in later conferences (for example, Yovits & Cameron 1960). Formal models of adaptation and evolutionary processes were proposed.

« 14 » In the years following the Macy conferences, cybernetics flourished and its ideas were taken up by many in many disciplines. Cyberneticians also found common ground with the followers of Ludwig von Bertalanffy, who were developing a general theory of systems (Bertalanffy 1950, 1972).

« 15 » By the 1970s, cybernetics, as a distinct discipline, had become marginalised. A number of reasons have been suggested for this. I believe two are particularly pertinent. The first is that, at heart, most scientists are specialists. Having taken from cybernetics what they found valuable, they concentrated on their own interests. Second, in the USA, funding for research in cybernetics became channelled towards research with more obvious relevance for military applications, notably research in artificial intelligence.[3] Attempts to develop coherent university-based research programmes in cybernetics, with attendant graduate level courses, were short-lived. However, some developments in the field that occurred in the late 1960s and early 1970s are particularly pertinent for the theme of this article.

« 16 » First, it is useful to note that the early cyberneticians were sophisticated in their understanding of the role of the observer. In the later terminology of Heinz von Foerster (see below), their concerns were both first-order (with observed systems) and second-order (with observing systems). It is the observer who distinguishes a system, who selects the variables of interest and decides how to measure them. For complex, self-organising systems this poses some particular challenges. Gordon Pask, in a classic paper, "The natural history of networks" (Pask 1960), spells this out particularly clearly. Even though such a system is, by definition,[4] state-determined, its behaviour is unpredictable: it cannot be captured as trajectory in a phase space. The observer is required to update his reference frame continually and does so by becoming a participant observer. Pask cites the role of a natural historian as an exemplar of what it means to be a participant observer. A natural historian interacts with the system he observes, looking for regularities in those interactions. Pask goes as far as likening the observer's interaction with the system with that of having a conversation with the system. Below, we will see how this insight of Pask was the seed for his development of "conversation theory."

« 17 » Second, the early cyberneticians had the reflexive awareness that in studying self-organising systems, they were studying themselves, as individuals and as a community. Von Foerster, in a classic paper from 1960 "On self-organising systems and their environments," makes this point almost as an aside. He notes:

> "[W]hen we […] consider ourselves to be self-organizing systems [we] may insist that introspection does not permit us to decide whether the world as we see it is 'real,' or just a phantasmagory, a dream, an illusion of our fancy." (Foerster 2003: 3f)

Foerster escapes from solipsism by asserting that an observer who distinguishes other selves must concede that, as selves, they are capable of distinguishing her. "Reality" indeed exists as the shared reference frame of two or more observers. With elegant, succinct formalisms, Foerster, shows how, through its circular causal interactions with its environmental niche and the regularities (invariances) that it encounters, an organism comes to construct its reality as a set of "objects" and "events," with itself as its own "ultimate object." He goes on to show how two such organisms may construe each other as fellow "ultimate objects" and engage in communication as members of a community of observers.

« 18 » This interest in the role of the observer and the observer herself as a system to be observed and understood led Foerster to propose a distinction between a first- and a second-order cybernetics, where first-order cybernetics is "the study of observed systems" and "second-order cybernetics is the study of observing systems" (Foerster 1974: 1). Foerster also referred to this second-order domain as the "cybernetics of cybernetics."[5] Of relevance for us here is that cybernetics is not only, as noted above, a discipline in its own right that can serve as a transdiscipline, cybernetics can also serve as a metadiscipline that studies not only itself but other disciplines, too.[6] I have discussed these aspects of cybernetics in some detail in Scott (2002).

« 19 » Again, for the purposes of this article, it should be mentioned that others had been thinking along somewhat simi-

3| For more on this, see Umpleby (2003).

4| The fundamental tenet of systems theory, cybernetics and computer science is that a system's next internal state and its output are a function of its current internal state and its input. These states and inputs and outputs are as distinguished and modelled by the observer.

5| For more detailed accounts of the events that led up to Foerster's making this distinction, see Glanville (2002) and Scott (2004).

6| It is of particular interest that, beginning with Wundt, many psychologists have considered psychology to be the "propaedeutic science" (Greek propaideutikos, i.e., what is taught beforehand) because what it says about human behavior and cognitive capabilities can shed light on how science works and how it can be carried out effectively by practitioners in other disciplines (and, of course, in psychology itself). See, for example, Stevens (1936). In more recent years "the psychology of science" has emerged as an active area of research. See, for example, Gholson et al. (1989) and Feist (2008). Worthy though the aims of this research are, it remains the thesis of this paper that they will be best achieved if psychology itself is properly founded using concepts from cybernetics.

lar lines to those of Pask and von Foerster. Humberto Maturana in his seminal paper, "Neurophysiology of cognition" (Maturana 1970a), frames his thesis about the operational closure of the nervous system[7] with an epistemological metacommentary about what this implies for the observer, who, as a biological system inhabiting a social milieu, has just such a nervous system. The closure of the nervous system makes clear that "reality" for the observer is a construction consequent upon her interactions with her environmental niche (Maturana uses the term "structural coupling" for these interactions). In other words, there is no direct access to an "external reality." Each observer lives in her own universe. It is by consensus and coordinated behaviour that a shared world is brought forth. As Maturana succinctly points out, "Everything that is said is said by an observer." In later writings (some written in collaboration with Francisco Varela), Maturana uses the term "autopoiesis" (Greek for self-creation) to refer to what he sees as the defining feature of living systems: the moment by moment reproduction of themselves as systems that, whatever else they do (adapt, learn, evolve), must reproduce themselves as systems that reproduce themselves. In explicating his theory of autopoiesis, Maturana makes an important distinction: the distinction between the "structure" of a system and the "organisation" of a system. A system's structure is the configuration of its parts at a given moment in time, a snapshot picture of the system's state. The organisation of a system is the set of processes that are reproduced by circular causality such that the system continues to exist as an autopoietic unity. In general, a system with this "circular causal" property is said to be "organisationally closed" (Maturana & Varela 1980).

« 20 » The ideas of Pask are particularly relevant for this article. Not only was Pask an early enthusiast of, and contributor to, cybernetics, he also had psychology as his core discipline. As noted above, Pask had an early interest in seeing interactions between an observer and a self-organising system as having the form of a conversation. Central in his research activity was the design of "teaching machines" and "learning environments" that interact with a learner, in a conversational manner, and adapt to the learner's progress so as to facilitate her learning. Pask was familiar with the work of Foerster and Maturana as a friend and colleague and drew on their ideas in creating his theory of conversations. As described below, Pask's theory is a much more fleshed out and elaborated account of human cognition, learning and communication than is to be found in the writings of either Foerster or Maturana.

« 21 » I shall begin my account of Pask's theory by disambiguating the terms "observer" and "observing system" as used in cybernetic writings. Usually, it is clear from the context that "observer" refers to a human observer capable of being a member of a community of observers. The term "observing system" is used more generally to refer to autopoietic systems. A single-celled organism, such as an amoeba, can serve as an example. An amoeba, to maintain itself as a unity, distinguishes itself from its environment. In its interactions with its environment, it adapts. The form of its organisation changes as a consequence of its interactions (its moment by moment structural coupling). As long as these changes do not affect the organisational closure of the system, the system persists.[8] The amoeba becomes "in-formed" about its environment. It has its own perspective on what is its environment, its "environmental niche." There is thus a sense in which to be alive is to cognise. Multicellular organisms with nervous systems that afford rapid transmission and receipt of signals and rapid self-referential operations no doubt have greater cognitive powers. One may speculate that the cognition of a porpoise (say) is qualitatively different from that of a tree.

« 22 » Although much of what Foerster and Maturana have to say is pertinent to humans, arguably it is Pask, the psychologist, who has given us the most comprehensive observer-based cybernetic theory of human cognition and communication. From the earliest stages of his thinking, he was aware that the human self develops and evolves in a social context and that "consciousness" (Latin con-scio, with + know) is about both knowing with oneself and knowing with others. Throughout his writings, from the 1960s onwards there is an acknowledgement by Pask of his indebtedness to the Russian psychologist Lev Vygotsky, who argued that, as a child develops, what begins as external speech eventually becomes internalised as an inner dialogue.[9]

« 23 » Pask, at an early stage in his theorizing made a distinction between a cognitive system and the "fabric" or "medium" that embodies it. This distinction is analogous to the distinction between programs and the computer in which they run. However, unlike the cognitivist science community, where the analogy is the basis of the thesis that both brains and computers are "physical symbol systems," Pask is aware that this interpretation of what is a symbol is conceptually naive.[10] He stresses how important it is to take account of the differences between brain/body systems and computing machinery. Brain/body systems are dynami-

7| The nervous system is an example of a circular causal system: it is a sensorimotor system in which what is done (motor "outputs") affects what is sensed (sensory "inputs") and what is sensed affects what is done (Dewey 1896). It is also worth noting (as stressed by von Foerster) that all sensing is a form of acting (sensory cells are primed to send signals to other cells when something happens that may be relevant for the whole system of which they are a part) and all acting includes sensing (by proprioception and kinaesthesia) what is being done.

8| It is worth noting that alongside the abstract cybernetic considerations of the systemic property of organisational closure, there is ongoing research in biophysics that seeks to understand the specific mechanisms by which living systems maintain themselves as coherent entities. See, for example, Mae Wan-Ho's review, in which she notes that none of the biophysical theories of the coherence of biological systems, as developed so far, is "as yet complete or fully coherent" (Ho 1995: 733). I suspect the search to understand the "glue" that holds living systems together will continue to be incomplete, just as other theories in quantum mechanics and cosmology remain incomplete.

9| Vygotsky's work, carried out in the 1920s and 1930s, did not become available in English until 1960 (Vygotsky 1962).

10| See Scott & Shurville (2011) for an extended discussion of this conceptual confusion within the AI/cognitive science community.

cal, autopoietic systems, whose structure is constantly changing, whereas computers are designed to be stable. In Pask's terms, there is an interaction between a cognitive system and its embodiment. A change in the structure of the brain/body system affects cognition. Changes in thinking affect the structure of the brain/body system. It is important to note that Pask's distinction is an analytic distinction, not an ontological one. It affords a way of talking about cognitive processes distinct from physiological processes.

« 24 » In the late 1960s, Pask adopted a new terminology. Brain/body systems and extensions are referred to as "mechanical individuals" (M Individuals). Cognitive systems are referred to as "psychological individuals" (P Individuals). M Individuals (with extensions, such as vehicles, pens and telescopes) are the "processors" that "execute" the P Individuals as cognitive "procedures." Both kinds of system are organisationally closed, self-reproducing systems. As we shall see in later sections, Pask's distinction between the two kinds of individual (or unities) is very useful for the aim of providing psychology with a coherent conceptual framework.

« 25 » In order to avoid some of the confusions a partial or shallow reading of Pask can lead to, I refer to P Individuals as "psychosocial unities" and M Individuals as "biological unities" or "biomechanical unities." Pask himself on occasion referred to conversation theory and his later development of "interaction of actors theory" as theories of the psychosocial (Pask 1996).

Cybernetics in psychology

« 26 » A key feature of cybernetic explanations is their use of models. The cybernetician Frank George proposes that a theory is a model together with its interpretation (George 1961: 52–56), where a model can be anything: marks on paper, a computer program, a mathematical equation, a concrete artefact. The key idea is that a model is a non-linguistic part of the theory. It is a form, a structure, a mechanism that can be manipulated by an observer and that maps onto the "real" system that the theory is concerned with. This is to be contrasted with many so-called "theories" that are to be found in the humanities, where metaphors and analogies are liberally deployed, without formal (non-linguistic) justification. Models are to be found throughout the sciences. What makes a model "cybernetic" is the inclusion of circular causality, for example, in a model of a control system, such as a thermostat. Non-cybernetic models feature "linear causality" only, for example, models that show how the magnitude of a variable is a function of the magnitude of another.[11]

« 27 » The mapping between a model and the system modelled has the form of an analogy relation, such as, "A is to B as C is to D," where A and B are parts or states of the model and C and D are parts or states of the system modelled. There may of course be a number of such relations. It is also relevant to note that metaphors are abbreviated analogy relations. For example, the term "The ship of state" is asserting that steering a ship is analogous to governing a nation state. Pask tersely defines cybernetics as "The art and science of manipulating defensible metaphors" (Pask 1975a: 13). Not only does this definition capture the idea of constructing and validating models, "manipulating" carries with it the idea that the observer is in a circular causal relation with the model and the system modelled and the use of the word "defensible" carries with it the idea that the observer is a member of a community of observers.[12]

« 28 » Prior to the advent of cybernetics, psychology's bias was towards reporting empirical findings. As theory, the best that behaviourism could offer was a model of the brain as a kind of telephone exchange where "stimuli" give rise to "responses." Gestalt psychologists used the concept of brain activity being "field"-like in an attempt to explain how perceptual inputs were reconfigured to conform to the "laws of pragnanz" (good form) in perception and problem solving.[13] Now models featuring circular causality can be found throughout psychology, for example, models of perceiving, problem solving, learning, remembering and skilled performance. However, their general form tends not to be highlighted. There is a focus on specific subdomains, rather than an appreciation that the models are part of larger general class.

Unifying "process" and "person" approaches

« 29 » By "process" approaches, I am referring to those that set out to model and understand some particular aspect of human cognition. As mentioned above, models for these processes abound in contemporary psychology, as an examination of standard texts will show (for example, Eysenck & Keane 2015). By "person" approaches, I am referring to those that concern themselves with a human being as a whole, albeit, possibly focusing on some particular set of attributes, such as "personality" or "intelligence." Whole person approaches are sometimes referred to as "humanistic psychology." My proposal here is that cybernetics, because it deals with both the processes that constitute the behaviour of parts of a system and the joint effects that constitute the behaviour of whole systems, can supply a conceptual framework that unifies the two approaches. I have written about this possibility elsewhere (Scott 2001a, 2011a, 2011b) and have drawn on two main sources, Pask and von Foerster.

« 30 » In the field of "cognitive science," which subsumes artificial intelligence research and certain approaches to cognitive psychology and the philosophy of mind, there have been several attempts to build a "unified cognitive architecture." See, as examples, Newell's SOAR (Newell 1990),[14] and Anderson's ACT-R (Anderson 1983).[15] Both systems are built from components. Both systems take inspiration from (and can be seen as embodying) theories of human cognition. Both systems are "artificial

11| For more on cybernetic explanations and cybernetic modelling, see Klir & Valach (1967) and Scott (2000).

12| For more on the use of analogies in science, see Hesse (1966). For more on the use of analogies in cybernetics, see Pask (1963).

13| In "hands-on" studies of the brain (neuropsychology), more sophisticated models were constructed, as in the classic work of Donald Hebb (1949), whose models are clearly "cybernetic" in the sense used here.

14| See also http://soar.eecs.umich.edu

15| See also http://act-r.psy.cmu.edu

intelligences" in their own right. In SOAR, every decision is based on current sensory data, the contents of working memory and knowledge retrieved from long-term memory, where long-term memory contains procedural knowledge, semantic memory and episodic memory. ACT-R's main components are: perceptual-motor modules, two kinds of memory module (declarative and procedural), buffers that access modules and a pattern matcher that matches buffer contents to the possible actions ("productions") stored in procedural memory. Further details are not relevant for the argument being made.

« 31 » In contrast, von Foerster makes clear that the components of a unified cognitive architecture are inseparable:

> "In the stream of cognitive processes, one can conceptually isolate certain components, for instance (i) the faculty to see (ii) the faculty to remember (iii) the faculty to infer. But if one wishes to isolate these faculties functionally or locally, one is doomed to fail. Consequently, if the mechanisms that are responsible for any of these faculties are to be discovered, then the totality of cognitive processes must be considered." (Foerster 2003: 105)

« 32 » More generally, von Foerster criticises "the delusion, which takes for granted the functional isomorphism between various and distinct processes that happen to be called by the same name." In this context, he mentions the misapplication to computing machines of the terms "memory," "problem solving," "learning," "perception" and "information" (Foerster 2003: 172).

« 33 » Theorising in any discipline needs foundations: somewhere to begin the telling of explanatory stories. In psychology, it has been common practice to begin with elementary building blocks, such as "habits," "expectations," "stimulus-response bonds," "memory states," "drives," "thoughts," "instincts," "cognitive processes," "feelings." I believe that von Foerster provides a cybernetic foundation for psychology with his concept of a "self-organising system," as set out in his 1960 paper "On self-organising systems and their environments." A self-organising system "eats energy and variety from its environment" (Foerster 2003: 6). The rate of change of redundancy in the system is always positive. The system is always becoming more ordered. The observer is continually obliged to update her reference frame.[16] He points out that, reflexively, the observer is just such a system. A classic example from the human domain is a human infant exploring its environment. Of course, metabolic requirements mean it has to rest once in a while as energy and variety are assimilated and accommodated.

« 34 » In later years, von Foerster refined the concept of a self-organising system, citing the concept of autopoiesis as a useful way to speak about an organism as an autonomous entity: "Autopoiesis is that organization which computes its own organization"; "Autopoietic systems are thermodynamically open but organizationally closed" (Foerster 2003: 281). I believe von Foerster's definitions are a very useful way of uniting the earlier and later literatures.

« 35 » In his studies of human learning and cognition, which lead to the development of his conversation theory (CT), Pask took von Foerster's concept of a self-organising system and made it a cornerstone of his theorising about the dynamics of learning, arguing that humans have a "need to learn." He refers to his interest in the whole system aspects of human cognition as "macrotheory."[17] In contrast, he refers to his (and colleagues') accounts of how human subjects construct particular cognitive structures as "microtheory." Pask (1975b) refers to the processes that are the parts of a cognitive system by the general term "concept." Pask's usage of the term is quite unusual as his concepts are dynamic processes. In mainstream cognitive science, concepts are typically thought of as relatively static representations.[18] Pask defines a concept as a procedure that recalls, recognises, constructs or maintains a relation. A concept may be likened to a program or operator that solves particular problems. "Relation" is used here as an empty slot or label for that which is being acted upon by the process as input or product.

« 36 » Recursively, there are concepts whose domain of application, whose input and products, are other concepts. This affords the construction of hierarchies of concepts. Thus, there can be problem-solver concepts, the task of which is to construct and select from amongst lower-level putative problem solvers, guided by feedback from the problem domain about the success or not of their application. Thus learning is an evolutionary process. One of Pask's very elegant definitions of learning is that it is the construction of a hierarchy of problem solvers (Pask 1975b). Micro and macro aspects of his theorising are married in the idea that "conceptualisation," the process of creating and recreating concepts, is an ongoing dynamic activity. A Paskian P Individual is a system of concepts that is self-reproducing. Particular hierarchies of concepts are seen to be temporary constructions and re-constructions within an overall heterarchical, organisationally closed system of processes.[19,20]

« 37 » In CT, in an effective learning conversation, the role of the teacher (human or machine) is to facilitate the learner's construction of new concepts. This is done

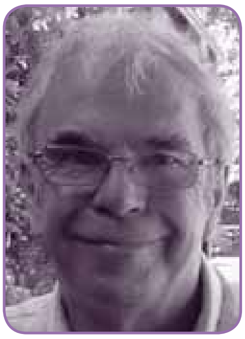
16 | Foerster (2003: 281) refers to Varela, Maturana and Uribe as the inventors of the idea and to their joint paper (Varela, Maturana & Uribe 1974) as the first statement of the idea in English. Elsewhere (Foerster 2003: 251), he notes that the general form of the closed system of recursively applied operations that constitutes autopoiesis was described by Maturana before it was named (Maturana 1970a, 1970b).

17 | Macrotheory is crucially concerned with giving some account of "awareness" and "consciousness" as being concerned with seeking variety and the consequent reduction of uncertainty. It is not possible here to address these topics satisfactorily, see Pask (1981) and Scott & Bansal (2014).

18 | Walter Freeman (2000) gives an elegant description of the differences between representationalist accounts of cognition and dynamic and "enactive" accounts from the perspective of contemporary findings in neuroscience. His arguments in favour of dynamic approaches are cognate with Pask's theorising.

19 | Within mainstream representationalist cognitive science, there have been attempts to develop theories of concept system dynamics. See, for example, Barsalou 2012). Arguably, these accounts are unsatisfactory because they lack the concept of an organisationally closed unitary system.

20 | For further discussion of these core ideas of CT, see Scott (2009).



BERNARD SCOTT
graduated from Brunel University, UK, in 1968 with a first-class honours degree in psychology. He completed a PhD in cybernetics from the same university in 1976. His supervisor was Gordon Pask, with whom he worked between 1967 and 1978. Bernard is former Reader in Cybernetics, Cranfield University, UK. He now a Senior Research Fellow with the Center for Sociocybernetic Studies. Bernard is a Fellow of the UK's Cybernetics Society. He is an Associate Fellow of the British Psychological Society, a Fellow of the American Society for Cybernetics and an Academician of the International Academy of Systems and Cybernetics Sciences. Bernard is Past President of Research Committee 51 (on Sociocybernetics) of the International Sociological Association.

by providing the learner with descriptions and demonstrations of what is to be learned, as part of an ongoing conversation. In return for these affordances to help in her learning, the learner is invited to say what she is aiming to learn and how she intends to go about it (what strategy for learning she has, if any). Periodically, the learner's understanding of new concepts is assessed by requiring her to "teach back" what she has learned.[21] With respect to this ongoing cycle of learner and teacher interactions, Pask not only views the two participants as self-organising systems in interaction, he also views the learning conversation itself as an emergent self-organising system, a P Individual (psychosocial unity) in its own right. As a generalisation, Pask then argues that all conversations are, at heart, learning conversations. In conversations, whatever else the participants are doing, they are learning about each other.

Unifying individual and social psychologies

« 38 » What is also innovative and unifying in Pask's conversation theory (CT) is the voiding of the distinction between the human individual and the social processes that are constitutive of him/her and that he/she constitutes. Pask agrees with George Herbert Mead, Leo Vygotsky, Martin Buber and von Foerster that the psychological individual is dialogical in form, *is* a social process, *is* constituted by an inner dialogue, *is* an inner conversation. As a good cybernetician, Pask abstracts from specific cases and voids the distinctions and thus argues that all conversations, all dialogues, all social processes are psychological individuals. They are all organisationally closed, self-producing, collectives of concepts (psychosocial unities). Thus, in ontogeny, individuals and collectives are co-evolving psychosocial unities. For an extended discussion of this view, see Scott (2007). We can now see the usefulness of making a distinction between M Individuals (biomechanical unities) and P Individuals (psychosocial unities) in that the two types of unity need not necessarily be in one-to-one correspondence. A single M Individual (a brain/body system, for example) may embody several P Individuals (the inner conversation). A single P Individual (the outer conversation that unifies a collective) may be embodied in several M Individuals.

« 39 » CT is useful for providing a conceptual framework that helps in understanding the dynamics of interpersonal perception and the pragmatics of human communication (see Scott 1987, 1997). As a reflexive theory of theory building (learning), CT accounts for its own genesis. Top down, it accepts that theories are the consensual constructions of communities of observers engaged in conversation, including conversations about conversation. As such, it is cognate with the "discursive" approach in the humanities and social sciences (also known as social constructionism).[22] Bottom up, its foundations lie in the cybernetics of self-organising systems and their interactions as described above.

« 40 » It is also worth noting that the CT concept of a psychosocial unity provides an alternative, cybernetics-based, concept of a social system to that developed by the sociologist Niklas Luhmann (1995). Luhmann distinguishes three kinds of "autopoietic" system:[23] biological, "psychic" and social. Pask's unification of the individual and the social distinguishes just two kinds of organisationally closed system: the biological and the psychosocial (M Individuals and P Individuals).[24]

Future directions

« 41 » There are two areas in which I believe an observer-focused cybernetics can continue to contribute to psychology and the cognitive and social sciences at large. One is conceptual clarification; the other as a foundation for and a reframing of the education of psychologists.

« 42 » As so ably pointed out by Hacker (op. cit.), conceptual confusion abounds in psychology, cognitive science and the neurosciences, not least in talk about "consciousness" as an ontological essence or of brains and computers having the same

21| For more details about CT's application in the design of a conversational learning environment, see Pask, Scott & Kallikourdis (1973).

22| As examples, see Gergen (1999) and Gergen, Schrader & Gergen (2009). The latter is a collection of readings; authors of contributions include Rom Harré, John Shotter, Steve Duck, Erving Goffman, Harold Garfinkel and Ludwig Wittgenstein.

23| Luhmann takes this term from Maturana and Varela to refer to systems that are self-reproducing and organisationally closed. His use of the term is controversial. See, e.g., Buchinger (2012) and the associated open peer commentaries.

24| Pask and Luhmann are compared more systematically in Scott (2001b) and Buchinger & Scott (2010).

ontological status as "physical symbol systems." Hopefully, second-order cybernetics will continue to do its job of conceptual ground-clearing, and the ongoing empirical and theoretical research into "minds," "brains," "individuals" and "societies" will be better conceived and more fruitful.

« 43 » Arguably, the education of psychologists should begin with an understanding of complex adaptive systems and the specific concept that humans are self-organising, autopoietic wholes that in their ontogeny and social interaction develop organisationally-closed cognitive and affective systems and become psychosocial unities (psychological individuals).[25] It should then set out, in broad-brushstroke form, the unifying conceptual framework I have sketched out above.

25| Elsewhere I have outlined a curriculum for "cybernetic enlightenment," which sets out some of my proposals in more detail (Scott 2014).

Conclusion

« 44 » I have proposed observer-based cybernetic foundations (with complementary first and second-order aspects) and a unifying conceptual framework for psychology and have argued for the value of my proposals based on the experience of how cybernetics served me. As an undergraduate, encountering cybernetics transformed my approach to studying and understanding psychology. It gave psychology a conceptual coherence that, previously, I had found lacking. In later years, as my understanding of cybernetics deepened, I continued to use second-order cybernetics as a foundation and framework for my work as an experimental psychologist (summarised in Scott 1993) and my later work as a practitioner in educational psychology (Scott 1987) and educational technology (Scott 2001c). The transdisciplinary and metadisciplinary nature of second-order cybernetics empowered me to read widely (and, on occasion, deeply) in other disciplines (logic, mathematics, computer science, philosophy, linguistics, the natural sciences, the social sciences).[26] Second-order cybernetics helped me learn how to learn. It helped me to appreciate readily the concepts and methods that inform other disciplines and their applications. I hope my account here will encourage others to explore, or to continue to explore, what second-order cybernetics has to offer.

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26| A propos of this, the developmental psychologist, Jean Piaget (1977: 136) writes, "Thus cybernetics is now the most polyvalent meeting place for physicomathematical sciences, biological sciences, and human sciences."

References

Ashby W. R. (1956) Introduction to cybernetics. Wiley, New York.

Barsalou L. W. (2012) The human conceptual system. In: Spivey M., McRae K. & Joanisse M. (eds.) The Cambridge handbook of psycholinguistics. Cambridge University Press, New York: 239–258.

Bateson G. (1972) Steps to an ecology of mind. Intertext Books, London.

Bertalanffy L. von (1950) An outline of general systems theory. British Journal for the Philosophy of Science 1: 134–165.

Bertalanffy L. von (1972) The history and status of general systems theory. In: Klir G. (ed.) Trends in general systems theory. Wiley, New York. ▸ http://cepa.info/2701

Buchinger E. (2012) Luhmann and the constructivist heritage: A critical reflection. Constructivist Foundations 8(1): 19–28. ▸ http://constructivist.info/8/1/019

Buchinger E. & Scott B. (2010) Comparing conceptions of learning: Pask and Luhmann. Constructivist Foundations 5(3): 109–120. ▸ http://constructivist.info/5/3/109

Chapman S. J. & Jones D. M. (1980) Models of man. The British Psychological Society, Leicester.

Conway F. & Siegelman J. (2006) Dark hero of the information Age: In search of Norbert Wiener, the father of cybernetics. Basic Books, New York.

Dewey J. (1896) The reflex arc concept in psychology. Psychological Review 3: 357–370.

Eysenck M. & Keane T. (2015) Cognitive psychology: A student's handbook. Psychology Press, London.

Feist G. (2008) The psychology of science and the origins of the scientific mind. Yale University Press, Boston MA.

Foerster H. von (1960) On self-organizing systems and their environments. In: Yovits M. & Cameron S. (eds.) Self-organizing systems. Pergamon Press, London: 31–50. Reprinted in Foerster H. von (2003) Understanding understanding. Springer, New York: 1–19.

Foerster H. von (eds.) (1974) Cybernetics of cybernetics. BCL Report 73.38. Biological Computer Laboratory, Dept. of Electrical Engineering, University of Illinois, Urbana IL. Republished in 1995 by Future Systems, Minneapolis MN.

Foerster H. von (2003) Understanding understanding: Essays on cybernetics and cognition. Springer, New York.

Foerster H. von, Mead M. & Teuber H. L. (1953) A note from the editors. In: Cybernetics: Circular causal and feedback mechanisms in biological and social systems, transactions of the eighth conference, 15–16 March 1951. Josiah Macy Jr. Foundation, New York NY: xi–xx.

Freeman W. H. (2000) Brains create macroscopic order from microscopic disorder by neurodynamics in perception. In: Arhem P., Blomberg C. & Liljenstrom H. (eds.) Disorder versus order in brain function. World Scientific, Singapore: 205–220. ▸ http://cepa.info/2702

George F. (1961) The brain as a computer. Pergamon Press, Oxford.

Gergen K. (1999) An invitation to social construction. Sage, London.

Gergen K., Schrader S. & Gergen M. (2009) Constructing worlds together: Interpersonal communication as relational process. Pearson Education, Boston MA.

Gholson B., Shadish W. R., Neimeyer R. A. & Houts A. C. (1989) Psychology of science:

Contributions to metascience. Cambridge University Press, Cambridge MA.
Glanville R. (2002) Second order cybernetics. In: Encyclopaedia of life support systems. EoLSS Publishers, Oxford. Web publication.
Gross R. (2010) Psychology: The science of mind and behaviour. 6th Edition. Hodder Education, London.
Hayes N. (2000) Foundations of psychology: An introductory text. Third edition. Cengage Learning EMEA, Andover.
Hebb D. O. (1949) The organisation of behaviour. Wiley, New York.
Heims S. J. (1991) Constructing a social science for postwar America: The cybernetics group, 1946–1953. MIT Press, Cambridge MA.
Hesse M. B. (1966) Models and analogies in science. University of Notre Dame Press, Notre Dame IN.
Ho M. W. (1995) Bioenergetics and the coherence of organisms. Neuronetwork World 5: 733–750.
Hunt M. (1993) The story of psychology. Doubleday, New York.
Klir G. & Valach M. (1967) Cybernetic modelling. Iliffe Books, London.
Leary D. E. (ed.) (1990) Metaphors in the history of psychology. Cambridge University Press, Cambridge MA.
Luhmann N. (1995) Social systems. Stanford University Press, Stanford CA. German original published in 1984.
Maturana H. R. (1970a) Neurophysiology of cognition. In: Garvin P. L. (ed.) Cognition: A multiple view. Spartan Books, New York: 3–24.
Maturana H. R. (1970b) Biology of cognition. BCL Report No. 9.0. University of Illinois, Urbana, Illinois. Reprinted in: Maturana H. R. & Varela F. J. (1980) Autopoiesis and cognition. Reidel, Dordrecht: 5–58. ▸ http://cepa.info/535
Maturana H. R. & Varela F. J. (1980) Autopoiesis and cognition. Reidel, Dordrecht.
Miller G. A. (1962) Psychology: The science of mental life. Harper and Row, New York.
Miller G. A., Gallanter E. & Pribram K. (1960) Plans and the structure of behaviour. Holt, Rinehart and Winston, New York.
Müller A. & Müller K. H. (eds.) (2007) An unfinished revolution? Heinz von Foerster and the Biological Computer Laboratory, BCL, 1958–1976. Edition echoraum, Vienna.
Newell A. (1990) Unified theories of cognition. Harvard University Press, Cambridge MA.
Pask G. (1960) The natural history of networks. In: Yovits M. C. & Cameron S. (eds.) Self-organising systems. Pergamon Press, London: 232–261.
Pask G. (1961) An approach to cybernetics. Hutchinson, London.
Pask G. (1963) The use of analogy and parable in cybernetics, with emphasis upon analogies for learning and creativity. Dialectica 2/3: 167–202.
Pask G. (1975a) The cybernetics of human learning and performance. Hutchinson, London.
Pask G. (1975b) Conversation, cognition and learning. Elsevier, Amsterdam.
Pask G. (1981) Organisational closure of potentially conscious systems. In: Zelany M., (ed.) Autopoiesis. North Holland Elsevier, New York: 265–307. ▸ http://cepa.info/2703
Pask G. (1996) Heinz von Foerster's self-organisation, the progenitor of conversation and interaction theories. Systems Research 13(3): 349–362.
Pask G., Scott B. & Kallikourdis D. (1973) A theory of conversations and individuals (exemplified by the learning process in CASTE). International Journal of Man-Machine Studies 5: 443–566.
Piaget J. (1977) Psychology and epistemology. Penguin, Harmondsworth.
Pickering A. (2010) The cybernetic brain: Sketches of another future. University of Chicago Press, Chicago IL.
Rosenblueth A., Wiener N. & Bigelow J. (1943) Behavior, purpose and teleology. Philosophy of Science 10(1): 18–24. ▸ http://cepa.info/2691
Sanford F. H. (1966) Psychology: A scientific study of man. Second edition. Wadsworth, Belmont CA.
Scott B. (1987) Human systems, communication and educational psychology. Educational Psychology in Practice 3(2): 4–15. ▸ http://cepa.info/1811
Scott B. (1993) Working with Gordon: Developing and applying Conversation Theory (1968–1978). Systems Research 10(3): 167–182. ▸ http://cepa.info/295
Scott B. (1996) Second-order cybernetics as cognitive methodology. Systems Research 13(3): 393–406. ▸ http://cepa.info/1810
Scott B. (1997) Inadvertent pathologies of communication in human systems. Kybernetes 26(6/7): 824–836. ▸ http://cepa.info/1809
Scott B. (2000) Cybernetic explanation and development. Kybernetes 29(7/8): 966–994. ▸ http://cepa.info/1807
Scott B. (2001a) Gordon Pask's contributions to psychology. Kybernetes 30(7/8): 891–901. ▸ http://cepa.info/1805
Scott B. (2001b) Cybernetics and the social sciences. Systems Research 18: 411–420. ▸ http://cepa.info/1804
Scott B. (2001c) Conversation theory: A dialogic, constructivist approach to educational technology. Cybernetics & Human Knowing 8(4): 25–46. ▸ http://cepa.info/1803
Scott B. (2002) Cybernetics and the integration of knowledge. In: Encyclopaedia of life support systems. EoLSS Publishers, Oxford. Web publication. ▸ http://cepa.info/1801
Scott B. (2004) Second order cybernetics: An historical introduction. Kybernetes 33(9/10): 1365–1378. ▸ http://cepa.info/1798
Scott B. (2007) The co-emergence of parts and wholes in psychological individuation. Constructivist Foundations 2(2/3): 65–71. ▸ http://constructivist.info/2/2/3/065
Scott B. (2009) Conversation, individuals and concepts: Some key concepts in Gordon Pask's interaction of actors and conversation theories Constructivist Foundations 4(3): 151–158. ▸ http://constructivist.info/4/3/151
Scott B. (2011) Explorations in second-order cybernetics. Reflections on cybernetics, psychology and education. Edition echoraum, Vienna.
Scott B. (2011a) Heinz von Foerster: Contributions to psychology. Cybernetics & Human Knowing 18(3/4): 163–169. ▸ http://cepa.info/1789
Scott B. (2011b) Toward a cybernetic psychology. Kybernetes 40(9/10): 1247–1257. ▸ http://cepa.info/1790
Scott B. (2014) Education for cybernetic enlightenment. Cybernetics and Human Knowing 21: 1–2: 199–205. ▸ http://cepa.info/1286
Scott B. & Bansal A. (2014) Learning about learning: A cybernetic model of skill acquisition. Kybernetes 43: 9/10: 1399–1411. ▸ http://cepa.info/1283
Scott B. & Shurville S. (2011) What is a symbol? Kybernetes 48(1/2): 12–22. ▸ http://cepa.info/1791
Sloan T. (2000) Critical psychology. Palgrave Macmillan, New York.

Stevens S. S. (1936) Psychology: The propaedeutic science. Philosophy of Science 3(1): 90–103.

Umpleby S. (2003) Heinz von Foerster and the Mansfield Amendment. Cybernetics & Human Knowing 10(3–4): 87–190. ▸ http://cepa.info/1876

Varela F. J., Maturana H. R. & Uribe R. (1974) Autopoiesis: The organization of living systems, its characterization and a model. Biosystems 5: 187–196. ▸ http://cepa.info/546

Vygotsky L. (1962) Thought and language. MIT Press, Boston MA.

Wiener N. (1948) Cybernetics. MIT Press, Cambridge MA.

Wittgenstein L. (1953) Philosophical investigations. Basil Blackwell, Oxford.

Yovits M. & Cameron S. (eds.) (1960) Self-organizing systems. Pergamon Press, London.