

that an element with nonconforming outputs may be excused if an input is nonconforming. The performance of each element is evaluated against its specifications in isolation. It is possible for all elements of a failing system to be excused on the basis of nonconforming inputs from other elements, e.g., in any case with nonconforming feedback, in which case the failure must be attributed to the system as a whole.

This requirements focus of the design engineer is in sharp contrast to the functional analysis of the systems analyst, who has no prior way of discriminating whether an element has a nonconforming input, or is failing to perform as it should in the context of its input, unless functional ascriptions can be made to the elements and rational requirements inferred from the functions and available means. The systems analyst only makes progress via comprehension of the function of the elements. To the systems analyst, functional description, rather than quantitative specification, is fundamental to analysis of design.

4.3 Structure, Function, and Process

As summarized by Gharajedaghi (1999, 112–113), the design approach to systems analysis iteratively examines structure, function, and process to develop understanding in terms of design. Iteration is necessary because, in the systems approach, process and structure co-produce function in the context of environment. Inquiry then becomes necessarily iterative because structure, function, and process are each co-produced by the others, as well as co-producing each other, so that developing a new understanding of each modifies the understanding of the others in a converging sequence of mutual dependence.

The producer/product relationship is Singer's framework for explanation in the world of complex objects without sufficient causation. In Singer's framework, producers are necessary but not sufficient for their products, in the manner of acorns being necessary but not sufficient for oak trees. Singer (1924; 1959) uses the producer/product relationship to develop a pragmatic theory of choice, purpose, and free will, and extends the relationship in various ways to account for reproducers, co-producers, potential producers, and other analogues for biological and ecological classes (Flower, 1942; Pennypacker, 1942). Systems analysis uses the same framework for developing an objective theory of function and purpose. Function is a joint product of structure and process in the context of a purpose inherent in the essential characteristics of a comprising system.

The key challenge satisfied by the producer/product model of the relationship between structure and function is explaining how a given structure can have multiple functions in the same environment, as is often observed in systems behavior. The answer offered is that a single structure in a single environment can result in multiple functions through multiple processes.

4.4 Distinguishing Systems Analysis from Other Functional Ascriptions

The theory of design presented here defines function in terms of rationalized interlocking producer/product relations among structure, function, and process, so that having a design entails having elements with functions. This design paradigm of systems analysis differs from currently prevalent etiological, welfare, and dispositional analyses of functional ascriptions (McLaughlin, 2001).

In systems analysis, no etiological conclusion is warranted about a system with manifest design, nor is any conclusion warranted regarding whether it, or anything related to it, benefits from its functionality, or even whether the object exhibiting design has the ability to work in the manner implicit in its design. Design in systems analysis is only an objective model for an inquirer developing understanding, i.e., answers to “why?” questions, to complement knowledge and information, i.e., answers to “how?” and “what?” questions.

Systems analysis differs from classical internal teleology on the one hand, and subjective Cummins (1975) functional ascriptions on the other, in attempting an objective analysis of functional characteristics: following Singer (1924; 1959), systems analysis equates functional characteristics of a system with observable behaviors and capacities, and wields rationality and economy as razors for reducing understanding to inter-subjective propositions.

In classical analysis, naturalistic teleology is internal to an entity and causes behavior; thus, although the behavior may be observable, the teleological characteristics are private to their possessor and objects of inference rather than observation to others (McLaughlin, 2001, 16–17). For Cummins, functional ascriptions are instrumental relations relative to a goal, which goal is determined by the analyst’s interest and thus is subjective to the analyst, rather than the entity. For Singer, writing in the pragmatic tradition, functional characteristics are identical with their publicly observable phenomena and therefore objectively accessible to observers, with neither the analyst nor the object of analysis (nor the creator, nor the commissioner, nor the user, nor the owner of an artifact) being in a privileged position relative to teleological ascriptions.

That the systems analysis concept of function is distinct from etiological, dispositional, and welfare views, can be shown by considering the example of design failure. Design failure – the universal failure of a type to work properly – is a familiar occurrence in industry, especially during product development. Yet artifact types that are universal failures still have a design, and their elements have functions, even if they do not work, have never worked, and never will work.

For systems analysis, the same can be true of natural organs, since systems analysis does not distinguish between organs and artifacts. That universal failures never work does not prevent systems analysis from comprehending the design of a universally nonworking organ, based on the razors of rationality and economy applied to relations among the elements of the organ and relations among the organs of the comprising organism. This places systems methodology squarely at odds with