Information and Organization 26 (2016) 116–126

Contents lists available at ScienceDirect

Information and Organization

journal homepage: www.elsevier.com/locate/infoandorg

Crafting theory to satisfy the requirements of systems science

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ARTICLE INFO

Article history:
Received 26 February 2016
Received in revised form 20 September 2016
Accepted 22 September 2016
Available online xxxx

Keywords:
Systems theory

ABSTRACT

Just as Lee, Briggs, and Dennis (2014) showed that a rigorous conception of "explanation" leads to requirements for a positivist theory to satisfy, and just as Lee and Hovorka (2015) showed that a rigorous conception of "interpretation" leads to requirements for an interpretive theory to satisfy, we show that a rigorous conception of "systems" leads to certain requirements for a systems theory to satisfy. We apply basics of systems science in general, as well as basics of Luhmann's (Luhmann, 1995; Moeller, 2006) systems perspective in particular. We illustrate these basics with empirical material from a case about the role of information technology in anti-money laundering. The example demonstrates that research in information systems, which has been informed by positivism, interpretivism, and design, can be additionally and beneficially informed by systems science — which, ironically, has been largely absent in information "systems" research.

1. Introduction

What is systems science, what are the requirements that systems science imposes on theorizing, and how can research on information systems benefit from and satisfy these requirements? A fundamental premise of this essay is that the academic discipline of information systems, in incorporating the word "systems" in its name (e.g., the Hawaii International Conference on *System* Sciences, Management Information *Systems* Quarterly), needs to take "systems" seriously. Ironically, this academic discipline has not availed itself of the rich intellectual heritage of systems science (of which some notable exceptions include the work of Checkland (2000) and of Alter (2013)). Following not only Lee, Briggs, and Dennis (2014) who examined how to craft theory to satisfy the requirements of explanation, but also Lee and Hovorka (2015) who examined how to craft theory to satisfy the requirements of interpretation, we examine, in this essay, how to craft theory to satisfy the requirements of systems science. However, in our discussion, we will clarify that we shall ground our reflections on systems principles that have their origins in the founders of systems theory (such as Bertalanffy), where such principles are at a higher-level of theoretical abstraction than the specifics of any systems-oriented methodology.

The next and second section of this essay will offer some of the basic, general, and widely agreed-upon features of systems science. The purpose is not to present all features of systems science, but to extract key ideas useful for differentiating systems theorizing from theorizing in positivism, interpretivism, and design so that researchers already familiar with the latter can perceive additional benefits and insights afforded by the former.

The third section will present features of the specific form of systems theorizing advanced by Niklas Luhmann (1927–1998), a scholar whose work has been increasingly felt in the information-systems research community. Luhmann adapted systems theory

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http://dx.doi.org/10.1016/j.infoandorg.2016.09.002
1471-7727/

in a way that is readily useful to the large school of behavioral research already ensconced in the information-systems research community.

In the fourth section of the essay, we will abstract, from the preceding discussion on systems science, requirements for systems theorizing to satisfy.

In the fifth section, we will apply these requirements in an empirical case of systems theorizing about the role of information technology in anti-money laundering.

2. Some basics of systems science in general

Diverse schools of thought characterize systems science no less than positivist science, interpretive science, and design science.

In this essay, we approach systems science as an empirical science where its object of study is systems in general, rather than systems of specific types, such as social systems, computer systems, and ecological systems (Klir, 2013). Therefore, statements that systems science makes about "systems" would be applicable across systems of specific types. In fact, the vision of the founders of the Society for General Systems Research in 1954 – Bertalanffy (1950), Boulding (1956), Miller (1978) and Rapoport (1950) – was exactly that: the gradual development of a science that would synthesize fundamental principles from different fields. It was the idea of a science that would evolve into a sort of meta-theory through which a diverse array of different phenomena – across different systems – would be described, modeled, and investigated. Hammond (2003), who traced the evolution of systems theory in her work on the history of systems theorizing, called the whole endeavor a *science of synthesis*.

Indicative of the long history of systems science and its relation to information is Leo Szilard's 1929 paper (Szilard, 1964), which exposed the difference between matter/energy and information, and from which the cybernetics paradigm eventually emerged. Also, it is generally acknowledged that Shannon and Weaver's *The Mathematical Theory of Communication* (Shannon & Weaver, 1949) is second only to Norbert Wiener's *Cybernetics* (Wiener, 1948) in establishing concepts for the evolution of systems thinking (including information, communication, and of course, feedback). Thus, the groundwork has already been laid for definitively establishing connections and identifying common core principles between systems science and the study of information systems.

Systems science is also known as "General Systems Theory" (GST). Overlapping versions of GST were rendered by Bertalanffy (1950), Boulding (1956), and others. Boulding emphasizes its generality by describing it as (Boulding, 1956, p. 208) "the skeleton of science in the sense that it aims to provide a framework or structure of systems on which to hang the flesh and blood of particular disciplines and particular subject matters in an orderly and coherent corpus of knowledge."

What, then, is a "system"? According to Bertalanffy (1950, p. 143):

> A system can be defined as a complex of interacting elements p_1, p_2 … p_n. Interaction means that the elements stand in a certain relation, R, so that their behaviour in R is different from their behavior in an another relation, R′. On the other hand, if the behavior in R and R′ is not different, there is no interaction, and the elements behave independently with respect to the relations R and R′.

As succinct as Bertalanffy's definition might be, it has ramifications of major significance that emerge when made explicit. Hegel, according to Skyttner (2005, pp. 49–50) formulated the following statements concerning the nature of systems.

- The whole is more than the sum of the parts [e.g., Bertalanffy's p_1, p_2 … p_n].
- The whole defines the nature of the parts.
- The parts cannot be understood by studying the whole.
- The parts are dynamically interrelated or interdependent.

Skyttner, moreover, offers a summary of properties of general systems for which he credits Bertalanffy, Litterer, and others (Skyttner, 2005, p. 53):

- Interrelationship and interdependence of objects and their attributes: unrelated and independent elements can never constitute a system.
- Holism: holistic properties not possible to detect by analysis should be possible to define in the system.
- Goal seeking: systemic interaction must result in some goal or final state to be reached or some equilibrium point being approached.
- Transformation process: all systems, if they are to attain their goal, must transform inputs into outputs. In living systems this transformation is mainly of a cyclical nature.
- Inputs and outputs: in a closed system the inputs are determined once and for all; in an open system additional inputs are admitted from its environment.
- Regulation: the interrelated objects constituting the system must be regulated in some fashion so that its goals can be realized. Regulation implies that necessary deviations will be detected and corrected.
- Hierarchy: systems are generally complex wholes made up of smaller subsystems. This nesting of systems within other systems is what is implied by hierarchy.
- Differentiation: in complex systems, specialized units perform specialized functions. This is a characteristic of all complex systems and may also be called specialization or division of labour.