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A Practical Approach to Modeling Complex Adaptive Flows in Psychology and Social Science

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Abstract

Five moments in the formation and functioning of complex adaptive systems are: (1) emergent regularities and patterns in the flow of matter, energy, and/or information; (2) condensed schematic representations of these regularities enabling their identification; (3) reproductively interchangeable variants of these representations serving as templates for new instances of the pattern; (4) successful reproduction facilitated by the accuracy and reliability of the representations' predictions of data flow regularities; and (5) informational feedback that adaptively modifies and reorganizes representations to incorporate new variations in the data flow, cycling back the first moment. These five moments are instantiated via stochastic models providing practical approaches to representing and managing complex adaptive psychological and social systems in education, health care, human resource management, etc. Local independence, unidimensionality, and statistical sufficiency criteria function as means of identifying, evaluating, and deploying conceptual and social forms of life acting as evolving agents in defined ecological niches. Bringing these agents into play systematically requires embodying them in technologies instrumental to making them readily recognizable and sharable across ecosystem niches. Modeling research and practice promoting sustainable and self-organizing ecosystems of this kind set the stage for redefining profit in terms of authentic wealth and value for life.

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Keywords: complex adaptive systems; psychology; stochastic models; Rasch models; self-organizing forms of life;

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1. Introduction

Living systems, from bacteria and viruses to plants, animals, and ecosystems to languages, societies, and economies, are complex adaptive systems characterized by five moments in their self-organizing processes [1]. Locating these five moments within a domain of practice, such as educational assessment or survey research, begins by tracing their embodiment through existing and proven research practices applying stochastic models of individual-level measurement [2-6]. Following the lead of recent research in agent-based modeling, this complex adaptive schema sets up a new practical art and science of instrument calibration and measurement that works from a bottom up flow of information. Instead of imposing policy from the top down on the basis of centralized data analyses, research and practice in a wide range of fields could perhaps more productively be provided media for their self-organization from the ground up.

2. Stochastic models and the opportunities they present

A broad array of stochastic models of individual-level measurement [2-6] present new opportunities for practical applications of agent-based models of complex adaptive systems [7-8] in designing, testing, and implementing information infrastructure ecosystems [9]. The local independence criterion tested by stochastic measurement models functions in effect as a way of identifying, evaluating, and deploying conceptual and social forms of life acting as agents in defined ecological niches. Bringing these agents into play systematically requires embodying them in technologies instrumental to making them readily recognizable, sharable, and habitually accessible. Such technologies could include common languages, shared metrics, and assessment instruments calibrated to be traceable to standard units of measurement, as shown in recent collaborations of metrology engineers and psychometricians [10-14].

Even when the methodological possibilities presented by adaptive instrument administration [15] and theory-informed unit standards are appreciated [16], the challenges in education, for instance, encountered in efforts aimed at bringing the world of varying curricula, pedagogies, assessments, and student abilities into a common framework of this kind may make such a framework seem impossibly unworkable. Decades of practical application of Rasch's models, however, suggest that coherent frames of reference aligning within-student development comparisons across students are feasible, viable, and desirable [17-21].

The phenomenon of noise-induced order [22], sometimes referred to as stochastic resonance [23], is a key characteristic of complex systems. Galison [24, pp. 843-844] encounters this kind of complexity in his extensive study of the material culture of microphysics, remarking on how the effectiveness of science stems from a kind of systematic disunity. By analogy, Galison points out that engineers have learned the value of amorphous semiconductors and laminated materials that fail microscopically but hold macroscopically when more homogenous materials collapse. The cultural import of this work stems from the fact that the disunity of science's communities of theoreticians, experimentalists, and instrument makers is not a function restricted or located solely in the domain of specific fields. It is, rather, fundamentally human in its incorporation of analogous linguistic and social complexities. Recognizing the pervasiveness of these patterns may provide a context for innovation that education and other fields could do well to emulate [25]. More fundamentally, the stochastic conception of error and uncertainty provides a basis for modeling meaningful quantitative interval units of measurement for emergent self-organizing forms of life [26].

2.1. Five moments in complex adaptive system emergence and function

The conception, gestation, birthing, and nurturing of complex adaptive systems constitute a reproductive logic for sociocultural traditions. Scientific traditions, in particular, form mature self-identities via a mutually implied subject-object relation absorbed into the flow of a mathematical dialectic. Complex adaptive systems establish the reproductive viability of their offspring and the coherence of an ecological web of meaningful relationships by means of this dialectic. Taylor [1, pp. 166-168] describes the five moments in the formation and operation of complex adaptive systems, which must be able:

- to identify regularities and patterns in the flow of matter, energy, and information (MEI, or data) in the environment;