Research Methods for Simple and Complex Systems

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Chapter 2) The Complexity & Predictability of Systems, are Important Concepts for Research and Experimentation

Over 1,450 words

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A Clarification of Concepts and Terminology That I am Using in this E-book

A Brief Description of Simple and Complex Systems, and Related Concepts

Based on the way am using the terminology, simple systems are studied in the physical sciences. This includes atoms, molecules, celestial bodies, chemical and nuclear reactions, as well as electronic and mechanical devices. This will be discussed in detail in the following sections.

Based on the way am using the terminology, **complex systems** are generally the systems studied in the biological, ecological, economic, psychological, and social sciences. These systems include human biology, psychology, and society. This will be discussed in detail in the following sections.

This chapter deals with complexity and predictability of systems, which is important for research and experimentation. Simple systems that are predictable do not require the same statistical evaluation, as complex systems that result in a high degree of uncertainty.

Important Note, About the Meaning of Predictability and Unpredictability of a System

Throughout this chapter, I talk about the predictability and unpredictability in relation to specific types of systems. I am

explaining what I mean by this terminology in the following two paragraphs.

Predictability of a system refers to the ability to predict its behavior, and the outcome of its actions. Predictable systems will display the same behavior and outcomes, under a specific set of circumstances. Experiments involving predictable systems can be reproduced by a number of experimenters, and identical results will be obtained. For example, most chemical reactions involve predictable systems, and they will yield the same products when they are repeated under the same conditions.

Unpredictable systems are just the opposite of the above. Their behaviors and the outcome of their actions cannot always be predicted. For example, experiments that involve human behavior will usually **not** produce identical results for each test subject.

Simple Systems, and Their Predictability

Simple Systems, and Examples

Simple systems have a small number of moving or active components. Because of the simplicity, their behavior, and the results of their actions are usually highly predictable. However, simple systems sometimes have millions of components, but they are still simpler and **usually** more predictable than complex systems, of the biological and social sciences.

Below are examples of simple systems that are highly predictable.

- The swinging motion of a pendulum
- The movements of the hands of a clock
- The orbital path of the planets and stars
- Most chemical reactions
- Physical phenomena, such as the laws of classical physics

Technological devices are relatively simple systems when compared to the systems of the biological and social sciences. Technological devices are usually highly predictable systems, when they are functioning properly. See the following examples:

- Refrigerators
- Radios
- Television sets
- Jet planes
- Automobiles
- Nuclear reactors

Computers are probably the most complex technological systems. This is apparent when the computer code comprising the software and the structural components comprising the

hardware are evaluated. This includes desktop and laptop computers, and related software.

Because of the complexity of computer systems, the behavior of a software package, used in a specific computer, is not always predictable. In addition, the creation of new software devices often involves some degree of trial and error. This is because the exact results of a sequence of computer code cannot always be predicted, because of the great degree of complexity that is involved. **However, computer systems are much simpler and more predictable, than the complex systems of the biological, psychological, social, ecological, economic, sciences.**

Note, there are Simple Systems that are Unpredictable

Sometimes systems that have few moving parts or active components are highly unpredictable. This is usually because the mechanism of the system is NOT understood, the system is malfunctioning, or the system was designed to produce unpredictable results. An example of a very simple system that is designed to produce unpredictable results is a roulette wheel.

Complex Systems, and their Predictability

Complex Systems, and Examples

Complex systems have a very large number of moving or interacting components, which usually makes these systems

partly or totally unpredictable. An example, of a complex system is the stock market, which is comprised of a large number of people that buy and sell stock. Because of the complexity associated with the large number of buyers and sellers, and their personal buying and selling philosophy, it is generally impossible to predict the precise behavior of the stock market, on a day-to-day basis.

A complex system is usually (but not always) a one-of-a-kind entity, but they may be similar entities with slight differences. For example, each individual is a complex system that is different from every other individual in some respects. Even identical twins display slight differences.

Note, on the Predictability of Complex Systems, To Clarify the Concept

The behavior, and the resulting outcome of the actions of complex systems, such as the above examples, often can be partly predictable, but **not** precisely predictable. Partly predictable, is generally **not** adequate for scientific research, in less the results are **not** expressed in terms of an absolute statement. Results of this nature can sometimes be expressed in probabilities, or in terms of other statistical concepts.

Generally, we deal with complex systems in our daily lives, and we generally have an approximate idea of the resulting behaviors, and responses. For example, most of us have a general idea of the response of our boss if we ask for a raise,

which can ultimately result in a yes or no. Because your boss is a complex system were **not** dealing with certainty, and the response may be a dismissal notice, reduction in salary, or a promotion with an increase in salary.

The Relative Degree of Predictability of Different Types of Complex Systems

Psychological, sociological, ecological, economic, and atmospheric systems are usually more unpredictable than biological systems. Biological systems are often relatively predictable, especially when simple biochemical or physiological processes are involved. However, when the chemistry involves new drugs or new physiological techniques the results can be quite unpredictable. Experiments of this nature can sometimes yield different test results for each test subject. This is usually seen when new drugs are tested before they are put on the market. Even when drugs are widely used for many years, they may produce unpredictable results in certain individuals. This can include allergic reactions, or adverse outcomes related to differences in genetics.

Examples of Systems that are Complex

Examples of complex systems that are partly or totally unpredictable are presented below, in approximate order of increasing complexity.

- Microorganisms, such as bacteria, and protozoa
- Green plants, such as trees, and crops
- The biology and behavior of animals, such as pets, wild animals, and livestock

- Ecological systems, in specific geographical areas, such as forests, rivers, oceans, cities, and rural localities
- The atmospheric system that relates to the weather
- Human beings in terms of biological systems
- The human mind and related behaviors, and responses to stimuli
- The functioning of a business, in terms of attracting customers, managing employees, earning profits, or losing money
- The collective behavior of people comprising a social group, an organization, a society, a cultural group, or nation
- The economy of a large industrial nation
- The social network of an individual, in relation to the day-to-day experiences of life, involving the interaction of family, friends, neighbors, acquaintances, and colleagues in the workplace
- Life circumstances, and how it affects the development of the individual in terms of physical and mental health, educational achievement, financial success, actualized values, major life choices, compliance with the law, habit formation, and miscellaneous behavior patterns

For Additional Information

The concept of simple and complex systems, in relation to research is continued in the next chapter, which can be accessed by clicking on the following link:

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video search page, which has a number of videos that relate to systems theory, **by Eric Berlow**, **16)** Video: Keynote Speaker: Combining Complexity Theory with Narrative Research

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