A General Model of Simple and Complex Systems
By David Alderoty © 2015

Chapter 10) How Do Simple and Complex Systems Differ
Over 2,050 Words

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THE FOCUS AND PURPOSE OF THE SYSTEM PERSPECTIVE PRESENTED IN THIS E-BOOK

To prevent confusion, I am placing the following statement at the beginning of each chapter in this e-book. Keep the ideas presented in the following three paragraphs, in mind as you read this e-book.

The main utility of a systems theory, especially the **General Model of Simple and Complex Systems,** is to assist in the study of systems, especially in terms of problem solving, goal attainment, and observational and experimental research. From a system perspective, all the relevant factors of a system are considered to obtain an objective. This can include the behavior and overall functionality of the system, its environment, its components, its structure, and related dynamics, cause-and-effect sequences, inputs, outputs, forces, energy, rates, time, and expenditures.

Examples of a system are atoms, molecules, chemicals, machines, electronic circuits, computers, planets, stars, galaxies, bridges, tunnels, skyscrapers, forests, rivers, streams, oceans, tornadoes, hurricanes, microorganisms, plants, animals, human beings, social groups, small businesses, organizations, political parties, cultures, and the human mind of an individual, including related behaviors and personality traits.

A systems perspective is also useful for writing projects. This involves writing about all the relevant factors of a system, in terms of a thesis, or topic.

The purpose of this e-book is to discuss and explain the many details associated with the systems perspective described above. This required twelve chapters, which are relatively short.

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How Do Simple and Complex Systems Differ

What is a Simple System

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A simple system has a relatively small number of components, or a large number of identical components. As a result, the behaviors of **most** simple systems are highly predictable. Examples of a simple system are a pendulum, a steam engine, a cup of water.

If you are carrying out experimental research that involves relatively simple systems, **usually** it is **not** necessary to use statistics, or correlations. This is because, each time you do the experiment, you will obtain exactly the same results (with only a few unusual exceptions). This is assuming the experiment is carried out in the same way, each time the experiment repeated. For example, if you put an electric current through a cup of water, it will always decompose into hydrogen and oxygen. This is assuming you are using the correct experimental technique.

Complex systems behave very differently than the above, which is explained in the next subsection.

What are Complex Systems

Complex systems contain a large number of components. Examples of complex systems are human beings, animals, and plants. Usually each complex system is unique, or one-of-a-kind. For example, it is not feasible to obtain several identical human beings, for an experiment, because each individual is different. Even identical twins that grew up together may have had slightly different experiences, which might show up in experimental results. Even with plants and lower animals it might be difficult or impossible to obtain an identical set of individuals for an experiment.

Usually, complex systems do not behave identically. If two scientists perform the same experiment, with complex systems, they will probably obtain slightly different results, even if the used exactly the same procedures. When experimental conditions are less than ideal, the results of two experiments can vary greatly, or even contradict each other. For example, if a psychological experiment is carried out with two groups of college students, the experimental results can differ, because of slight cultural and/or psychological differences between the two groups of college students.

Generally, complex systems are always changing in some way, which might interfere with experimental results. For example, human beings are complex systems, and they might behave, and respond differently from one day to another. These variations can result from the psychological impact of daily living, such as recently experienced: failures, successful outcomes, conflict, learning, etc. There are also physiological variations from one day to another, which can influence behavior and emotional responses. Some simple examples are lack of sleep, a lowered blood sugar level, as a result of skipping a meal, or an illness.

As a result, of the above the experimental techniques used with simple systems, will **not** work well with complex systems. With complex systems, it is necessary to use various statistical methods, including calculations that involve averages, and correlations.

With complex systems, especially human beings, experimentation is **not** the only investigative strategy. Surveys are often used to evaluate the attitudes, behavior, and lifestyle of a social group, or segments of a population. The survey results require statistical evaluations. Another research strategy that is useful for complex systems is observation, especially for animal and human studies. This can be somewhat subjective, especially when evaluating people.

Simple Systems that are Not Predictable

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Certain types of simple systems are unpredictable. This can happen when it is not possible to measure all the relevant data to make accurate predictions. This can involve an inability to measure the forces and/or movements of the components of the system. These systems may be quite small, such as **individual:** subatomic particles, atoms, and molecules. This also includes the Brownian motion of the particles (such as dust) suspended in a gas, or liquid. All of the above display random movements, primarily because we cannot detect all of the forces that are acting on them, such as collisions with other particles.

Movements of large particles are usually predictable, such as planets and stars. This is because we can usually determine their initial movements, and the gravitational forces acting on them.

A List of Systems Based on their Complexity

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Most, **but not all**, simple systems are highly predictable, and it is usually unnecessary to use statistical methods to evaluate experimental results. Highly complex systems are usually social, psychological, and/or biological systems. In general, it is usually necessary to use statistical methods to evaluate experimental results with these complex systems.

Below there is a list of systems based on their complexity. The list starts with the simplest system and proceeds to the most complex.

- *A pendulum*, is one of the simplest, and most predictable systems.

- *Devices operated by muscle power, such as a bicycle, stagecoach, hand-operated drill*, are simple systems, and their functionality and behavior is usually highly predictable.

- *Small particles are simple systems, such as protons, neutrons, electrons, atoms, and molecules.* Because of the small size of these particles, and the speed in which they move, we cannot predict the precise behavior and movements of these particles. When dealing with a number of these particles, their behavior can be approximately predicted based on statistics. However, when dealing with huge quantities of these particles, such as in everyday life, and in chemistry, their collective behaviors are highly predictable. For example, when you place a pot of water on the stove, you can be certain of the results.

- *Celestial bodies, such as the moon, sun, and stars* are simple systems, and their movements are usually highly predictable.

- *Electronic devices that are comprised of a few components, such as a light bulb, a doorbell, headphones*, are simple systems, and their behavior is highly predictable.

- *Radios, televisions, refrigerators, washing machines, automobiles*, are moderately simple systems, and their behaviors are very predictable, when they are functioning properly.

- *Computer-based devices and related **software**, such as desktop computers, cell phones, and computer-networks*, are probably the most complex devices created by human beings. However, these devices are relatively simple when compared to most biological systems. Computer-based devices are usually quite predictable, except when they malfunction.

- *Single cell microorganisms, such as bacteria, amoeba, and paramecium* might be more complex than any device created by humans. The exact movements and behaviors of an individual microorganism are generally unpredictable. However, approximate predictions of movements and behavior can be made, which are likely to be fairly accurate.

- *Arthropods, such as insects, spiders, centipedes, shrimp, lobsters, and crabs, and scorpions* are complex systems, and the **precise** movements and behaviors of individual animals are generally unpredictable. However, approximate predictions of movements and behavior can be made, which are likely to be fairly accurate.

- *Birds* are complex systems, and the precise movements and behavior of an individual bird is generally unpredictable. However, approximate predictions of movements and behavior can be made, which are likely to be fairly accurate, in most cases.

- *Four-legged mammals, such as rats, cats, lions, tigers, leopards, and dogs* are highly complex systems, and the **precise** movements and behaviors of individual animals are generally unpredictable. However, approximate predictions can be made, which might be moderately accurate.

- *The most complex entities are human beings*, and systems comprised of people, such as social groups, organizations, political parties, and societies. The movements and behaviors of these systems usually cannot be precisely predicted.

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Size of Systems, in Terms of Five Levels, From Subatomic Particles to Galaxies

Introduction to the Physical Size of Systems, General Model of Simple and Complex Systems

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I am dividing the sizes of systems into five primary levels, which affect their properties, and predictability. I am starting with the smallest and proceeding to the largest, as presented in the following five subheadings.

Level 1) Subatomic, Atomic, Molecular, Colloidal Particles General Model of Simple and Complex Systems

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The smallest systems are at the subatomic, atomic, molecular, and colloidal levels. Atomic and molecular levels can be imaged with very powerful electron scanning microscopes. The colloidal level can be seen with conventional light microscopes. Some colloidal particles are large enough to be seen with the naked eye, such as dust particles floating in air.

As previously explained, the movements of individual particles in this category are usually unpredictable, because of their small size, and high-speed. Molecules and atoms can move and/or vibrate at billions, or trillions of **diameters per second**. Colloidal particles usually move slowly. However, there movements are the result of collisions with molecules, which are moving randomly at relatively high velocities.

For additional information, or tentative points of view, see the following websites, from other authors. **1)** Engineering Quantum Manipulating atoms and molecules for practical applications, by Dr. Jaime Ramirez-Serrano, **2)** Basic Information, Nanotechnology 101, **3)** Nanotechnology, **4)** Advances in Atomic & Molecular Nanotechnology, by G.Ali Mansoori.

Level 2) Visible Systems, Without Significant Gravity, General Model of Simple and Complex Systems

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The systems that we experience in our daily life vary greatly in size, which range from a grain of salt, to giant skyscrapers. However, all of these items are too small to have a significant gravitational force, and they are ultimately held together by molecular forces. Additional examples of systems in this category are insects, plants, mammals, people, trucks, trains, and giant aircraft carriers.

Level 3) Systems with Gravity, but Less Massive than a Star. General Model of Simple and Complex Systems

There are many systems are large enough to possess significant gravitational forces, but are less massive than a star. Examples are large asteroids, moons, and planets. Gravitational forces tend to influence the behavior and movements of these systems. Because of their gravitational forces, these systems may attract objects from space, such as meteorites. Systems in this category, which are the size of Earth or larger, **might** have an atmosphere, as well as a hot internal core with very high pressures. The atmosphere, and the hot internal core with high-pressure, is the **indirect** result of gravity.

Movements of these systems in this category are usually very predictable, because we can easily identify their initial movements, and the gravitational forces acting on them. In terms of **diameters per second**, they usually move quite slowly, such as a fraction of a diameter per second. This is the reason the moon and planets appear to be stationary or moving very slowly, when observed with the naked eye. However, planets may be moving at a rate greater than 10 miles per second, but because of their large diameter, this does **not** interfere with observations.

Level 4) Systems in the Form of Stars

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Stars are very large systems that have very strong gravitational forces that produce very high temperatures and pressures, especially in their central core. The strong gravitational field produce a great deal of heat and very high temperatures because of friction, and the compression of matter. The temperatures and pressures in the central core of stars are sufficient to start a nuclear reaction, which produces much additional heat and light. This is especially the case when there is hydrogen available.

The movements of stars are generally quite predictable, because they move at a relatively slow rate, **in terms of diameters per second**. However, stars generally move at very high velocities, but this does not interfere with observations because of their very large diameters.

Level 5) Galaxies and Black Holes

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Galaxies are extremely large systems, comprised of a huge number of stars, held together with gravitational forces. Galaxies are likely to contain other objects that do not generate light. This includes dust, rocks, asteroids, moons, planets, and black holes.

Black holes are comprised of a huge masse of material, which results in very strong gravitational fields. Because of the strong gravitational field matter, and light cannot escape from a black hole.

It is believed that black holes are created from stars that run out of elements (such as hydrogen) needed to maintain a nuclear reaction. When this happens, the star eventually collapses into a relatively small, highly dense mass.

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