1.2 How complexity hides in systems

Why do we find some situations complex and others simple? One explanation is the way we make sense of the world. We construct our own personal mental models or pictures of reality to make sense out of what we're experiencing, and to help us make decisions.

When you see a traffic jam, you think there must be an accident ahead. When you feel tired you think you mustn't have slept enough the night before. Thinking is about sense making. It is the skill of filling gaps in evidence to make sense of a situation.

Let's use the Kanizsa triangle as an illustration. How many triangles can you see here? Two, six, eight? Well, there aren't any. In any case, none have been drawn. Your brain receives pieces of information and fills in the gaps. You "make sense" of the information you receive based on your knowledge that comes mainly from your training and past experiences. Here we use our knowledge of triangles to fill in the gaps.

We all use mental models to construct useful representations of the world we live in and the relationships that exist between the elements. They help us select what information to notice, learn, remember or infer in any situation[1]. They act as mental maps that help us interpret the past, the present and develop expectations for the future.

All models, mental or otherwise are simplifications but if we want to think, we have to use them. And therein lays the problem. We have a number of cognitive difficulties constructing accurate mental models of complex situations. Most of these go back to our education and the way we have learnt to deal with the world around us.

For the past four centuries we have often taken things apart to better understand them. This approach is what we call "analysis". Analysis comes from the Ancient Greek ἀνάλυσις, meaning "to unravel, to investigate". Analysis was originally suggested by the French philosopher René Descartes in the 17th century in his work "Discours de la méthode". It involves reducing complex phenomena into their component parts, studying each part individually and then adding up our understanding of all individual parts to form an understanding of the whole.

The British scientist, Sir Isaac Newton combined Descartes' logic and rigor with the experimental practice of Italian astronomer and mathematician Galileo Galilei during the scientific revolution. Analysis was thus placed at the heart of the scientific method and has allowed the sciences to make amazing progress over the past 400 years.

In fact, analysis has been so successful in science that we are tempted to use it whenever we have a problem to solve. We tend to break problems down and study each part individually and then build a comprehension of the whole from a detailed understanding of each part.

However, this approach doesn't work if the parts are connected and in interaction. When two or more elements are interconnected we have a system. If we take a system apart, we break it because we break the connections between its parts. A system is a "a collection of parts which interact with

[1] Markus, H. (1977). Self-schemata and processing information about the self. *Journal of personality and social psychology*, *35*(2), 63.

each other to function as a whole"[2] To understand and anticipate the behavior of a system it should be studied as a whole. To influence or control a system, it must be acted on as a whole.

Systems theory emerged in the early 20th century as a response to a growing number of problems that were proving difficult to solve using traditional analytical techniques. Systems theory is the study of systems of interconnected parts and provides us with models and methods to help better understand complexity. By reasoning in systems, rather than about objects or things, we focus on the interconnections between the parts and are better equipped to deal with the complexity they generate.

One of the first major works published on systems theory was the book "General System Theory" by Ludvig Von Bertalanffy, a biologist. Von Bertalanffy demonstrated that biological, physical and social systems all share common features such as feedback and emergent behavior. MIT professor Jay Forrester later introduced the key notion of accumulations when he developed a set of applied concepts and tools to help study the dynamics at work in complex social systems in the 1960s.

Since the 1980s, complexity theory has built on systems theory with inputs from such diverse fields as artificial intelligence, ecology, linguistics, computer science, economics, immunology and philosophy. Systems concepts are central to much of the work being done in complexity science today.

[2] Kauffman, D. L. (1980). *Systems one: An introduction to systems thinking*. Minneapolis, MN: Future Systems, p.1.