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Introduction

In these times of liquid modernity, the pressures of which can lead to increased tensions between individuals, groups, societies and countries, while at the same time requiring the same to unite in order to find and implement solutions to global challenges, it is more than ever important to understand what we are undertaking when we interact. This talk looks at how complex systems theory can be applied to human interaction in order to allow those interested to obtain a better grasp on the enormity of interaction and the delicatesse and skill needed in order to navigate it.

Complex systems

Imagine a plant and how it grows from a seed. The seed sprouts and grows. The cells split again and again to form the leaves, stalk, possibly flowers and roots each with their own interconnected role to play in the life of the plant. The plant needs water and nutrients, air and soil, light and temperature, space and time. All of these internal and external factors contribute to the healthy growth, or not, of the plant. A plant can be considered to be a complex system.

What are complex systems?

There is no single definition of what a complex system is which means that there are many perspectives on the subject. A complex system is a special class of system.

So, what is a system? As opposed to a set, which is merely a group of unordered components, a system is a group of components and relations between them.

With a set there is no order; the group can only be described by describing the properties of the individual components. The set is merely a sum of its individual components. This is not the same case with a system. In a system the components can function together as a whole due to the relation between them and the fact that they are ordered in a specific way. Thus a system is a group of components interacting with one another and forming a whole, leading to the creation of a new level of organisation.

The multiplicity of the number of components is an important factor in what makes a system a complex one. Nevertheless, it is not only the vast number of components that makes a system complex, but in particular the heterogeneous and independent nature of these components which mean that their behaviour cannot be predicted.

The components in a complex system are distributed without centralised control. This means that there is not one main component steering or guiding the others, or from which the other components stem. Based on the feedback from the feedback loops that exist in such systems, they self-organise in the different parts of the system in order to create balance and this gives rise to new levels of organisation over time and space. This phenomenon is called emergence.

With this emergence, a whole new level to the system is developed which interacts then with other parts of the system leading to new patterns of organisation, which in turn results again in the emergence of another level of organisation. This emergent process keeps repeating itself. The components are nested inside sub-systems which in turn form part of larger systems.

Features of complex systems

Studying a complex system means looking at the collective behaviour of the system as opposed to adopting a reductionist approach which aims to explain the parts comprising the system individually and the individual relationships between those parts.

It is interesting to take a systems thinking approach when applying complex systems theory to a phenomenon such as interaction because it allows us to envision this in an overarching way, rather than focussing on the individual components as has usually been the case. Dianne Larsen-Freeman, one of the most well-known researchers on complexity theory in applied linguistics points out that 'adopting a systems perspective on issues of interest in applied linguistics, rather than a piecemeal approach, made a great deal of sense to me. I had grown somewhat discouraged by common research approaches to second language acquisition (SLA) as I understood them. I found them to be reductionist, atomizing the object of concern and then studying one atom at a time, often through single treatment, pre-test-post-test designs. Controlling for other factors and overly deterministic, it sought to identify the causal factor in SLA, e.g., comprehensible input at ani+1 level.' (Larsen-Freeman, 2013).

Complex systems have certain features, they are:

Non-linear: the system is unpredictable, random; it does not progress smoothly from one step to another. 'A system is non-linear when the cause of its effects can be easily identified and the effects are always directly proportional to the cause. A non-linear system is an indivisible whole that exhibits emergent properties. In a non-linear system a cause can produce no effect at all, or a tiny cause may produce even large effects' (Baicchi, 2015).

Interconnected: high levels of interconnectivity between components are found in complex systems. 'Many definitions for complex systems involve dense or high levels of interconnectivity between components' (Colchester, 2016). The connections between components can grow exponentially.

Emergent: the whole system is different to the sum of the characteristics or properties of its components, again it is unpredictable. The self-organisation of the components at the local level gives rise to the emergence of new levels in the system, which in turn leads to further emergence. Sandra Mitchell writes: 'Self-organization refers to any set of processes in which order emerges from the interaction of the components of system without direction from external factors and without a plan of the order embedded in an individual component' (Mitchell, 2003)

Spontaneous: the system can behave in a certain way but we do not know when a certain behaviour will be manifested, or indeed whether it will occur at all. There are a variety of different responses for any given phenomenon. 'Each system spontaneously generates its own pattern of action, its interpretative order, and is different from the sum of its own parts.' (Pinazo-Calatayud, 2006)

Adaptable: the system can change, it is flexible, it can learn from experience. There is no top-down, centralised mechanism for coordinating the whole system. Components have a degree of autonomy often due to their ability to adapt to their local environment according to their own set of instructions. 'With autonomy and adaptation also come the capacity for a variety of different responses for any given phenomenon, meaning complex systems are often heterogeneous with high levels of diversity' (Colchester, 2016).

Contain feedback loops: the different components in the system can send information back about what happens when they are stimulated in order to update the system or add to the system's overall knowledge in order to potentially behave differently or more efficiently and better in the future. All the levels of the system affect one another.

Items in complex systems

Complex systems contain certain items:

Components: these are nodes; points of information. 'Complex systems: they are constituted by many non-identical elements (nodes) connected by diverse interactions (links)' (Moreno, 2014)

Links: these are connections between the components.

A boundary between the system and its environment: it is important to understand that there is a boundary to the system. The environment that the system operates in can have an impact on the system and the internal evolution of the system can have an impact on the environment. 'An essential feature of boundaries is that they can be crossed. There are more open boundaries and less open ones, but they can all be crossed' (Baianu and Poli, 2011).

Balance in complex systems

As well as boundaries, it is important to consider how a complex system maintains itself. In order for a system to exist it must maintain itself, otherwise it can disintegrate. 'If a system can reach a critical point, the system will face the possibility of breaking down even without the influence of any external force' (Lin et al., 2013) Complex systems self-organise to achieve a certain equilibrium contributing to their maintenance.

What are Complex <u>Adaptive</u> Systems?

Complex Adaptive Systems (CAS) are special cases of complex systems. Research on this type of system started about thirty years ago.

Complex Adaptive Systems change their behaviour in response to their environment. What distinguishes them from other complex systems is that the adaptive change that occurs is often relevant to achieving a goal or objective. A Complex Adaptive System seeks to improve its performance based on the feedback it receives.

Another important feature of Complex Adaptive Systems is that they are evolutionary:

One example of a Complex Adaptive Systems would be the stock market.

What are supercomplex systems?

We now arrive at the key concept of this talk: *supercomplexity*. When several complex systems are all interconnected and cyclical they form a supercomplex system. The different complex systems forming the supercomplex system are called sub-systems. If the supercomplex system is made up of complex adaptive systems, then it can be called a Supercomplex Adaptive System.

Features of supercomplex systems

Supercomplex systems have the same features as complex systems and also others, in particular causal dependency and anticipation.

Causal dependencies: the different systems depend on one another in some way. The systems have an impact on the behaviour of one another.

Anticipation: this is one feature that distinguishes living systems from non-living ones. Anticipation means that the system contains an internal predictive model of itself and its environment allowing it to change in accordance with the predictions of a later state.

What is interaction?

We can define interaction as being some form of engagement between humans or other types of beings, animals for example, and their environment. Dictionaries give the following definitions of interaction: 'an occasion when two or more people or things communicate with or react to each other' (Dictionary.cambridge.org, 2019), 'the process by which different things affect each other or change each other' (Macmillandictionary.com, 2019). This engagement could take the shape of communication or involvement of one kind of another.

I personally see interaction taking shape in different ways. One way is as a flow of some kind of coming together between animate and also inanimate beings connected to the surrounding environment, for example all the interaction that takes place in a given place; a house, a school, a supermarket, a town, a city, a country. Another way is as a flow of instances of coming together connected to each and every interactant; all the engagement a being, or inanimate object, has in their lifetime. At the same time I also think of interaction as interaction episodes. This is when the environment and the interactant come together alone or with other interactants for a given 'event', for example in order to buy something in a shop, to meet someone for a meal, to attend a lecture. These interaction episodes or events can themselves be broken down into sub-events or sub-episodes. These different flows and events can overlap and be linked with one another, merging together at different times and in different spaces.

What makes interaction a supercomplex adaptive system?

If we consider that the supersystem is interaction, the sub-systems are the different complex adaptive systems that contribute to interaction. By using the term sub-systems, or later sub-components, I am not suggesting a hierarchy of importance, but rather one way to explore the supercomplex system. Bearing in mind that these sub-systems, components and the overarching system is in a constant state of change.

Teaching about interaction

Effective interaction learning

Given that in the previous section I outlined what should be avoided in teaching about interaction, the question to be asked is what makes for effective interaction learning, then? I would say that first and foremost this is learning whereby learners become aware of what they are navigating when interacting with others. They can understand the supercomplexity involved in engaging in interaction and they avoid Othering.

By 'effective' I mean that learners are able to achieve their interaction objectives, whatever they may be, in a very broad way, and obtain a sense of satisfaction from the interaction they engage in. This is a similar approach to effectiveness as adopted in the field of organisational behaviour.

In order for learners to understand the supercomplexity of interaction they need to be taught about complex systems.

At the same time it has been shown that it is a challenge to teach learners about complex systems This means that new tools and techniques need to be developed in order to teach about complex systems in interaction and to foster effective interaction in learners.

In order to gain and develop knowledge of the supercomplexity of interaction learners need to understand it on a cognitive and affective level (Bloom et al., 1956) For the cognitive level this means, for example, that it needs to be explained and critical thinking and engagement about it should be developed (Cognitive processes in critical thinking, 2009, Conway, 2017).

There are different methods for developing cognitive aspects of complex systems. Again, what is clear is that traditional methods are not always adapted to teaching about complex systems 'Familiar teaching approaches typically try to reduce complex systems into their parts so they are easier to understand. Then we tend to look for linear cause-and-effect relationships between these separate parts. Doing this is a problem because it ignores the essence of the dynamic whole that makes the system what it is. We need to find new ways to keep the wholeness, while still making the parts accessible.' (Kupers, Hipkins and Drake, 2015).

One method for teaching about complexity has been put forward by Brian Sztabnik. He says that it is necessary to adopt three steps: start with a simple thought, ask questions in order to add layers, find the thread connecting these layers.

Fostering heartfulness

When learning about interaction learners should also engage their affective level of learning. To do this they need to be reflexive and draw on their emotions. One concept that can help learners become aware of their own emotions in order to navigate this supercomplex adaptive system and perhaps then act on them in order to become more effective in interaction is heartfulness.

Heartfulness can be described as 'The fact or quality of being heartful; sincerity or warmth of feeling or expression.' (Oxford Dictionaries | English, 2019). According to Carmen (Carmen, 2015) heartfulness is 'a state of being where the centre or locus of control is the heart; not the physical heart as a pumping station of blood, but the 'spiritual' heart as the guiding principle in one's life.' She

goes on to write about how intellect is often less of the determining force in our personal interactions and decision-making. It is our heart that drives our decisions, more often than our mind.

There are three areas where heartfulness can be involved in teaching about interaction: it can be included in the teaching method itself, that is to say the teacher adopts a heartful approach to teaching about interaction. Heartfulness can also be drawn on for helping learners to understand the supercomplexity of interaction on an affective level, and it can be adopted in the actual interaction of learners in cases where heartful interaction is sought.

When heartfulness is practiced in teaching interaction, this creates a positive climate for opening up to the supercomplexity of interaction which brings us back to what Jacobson and Wilensky said is needed for learning about complex systems.

Results and future orientation

The last part of my presentation will be devoted to the results of recent research and recommendations for the future orientation of further research.

Please refer to the PowerPoint slides uploaded to the conference website.