

Language as a Complex Adaptive System

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Abstract

This paper discusses the idea that language should be thought of as a complex adaptive system (CAS). A CAS is an open system that is made up of many individuals and types of individuals that all interact in various and complex ways, and that is in a constant state of flux. Firstly, I will briefly introduce four general examples of CAS; ecosystems, the solar system, economies, and traffic networks. I will then generalise some of the characteristics that they have in common. Finally, I will discuss how these characteristics apply to language as a CAS, and what the implications of that are for us as teachers and researchers.

Key words: Complexity, Adaptation, Systems, Emergence,

Introduction

The leading proponents of the study of language as a complex adaptive system (CAS) are the “Five Graces Group” (Beckner et al., 2009), which includes such prominent applied linguists as Diane Larsen-Freeman, Nick Ellis and Joan Bybee, to name a few. Complexity theory offers a very elegant explanation of a wide range of natural phenomena. It sees language as just one phenomenon among many that occur in nature. It is a theory that has been applied to other natural phenomena in disciplines as diverse as astrophysics, biology, historical anthropology, marketing, etc. The big advantage of this from the point of view of language study is that it does not require any innate human language trait, such innatist views posit a universal grammar or language acquisition device (LAD) (Chomsky, 1964) that does not appear to occur anywhere else in nature. It is tempting to think that those behaviours considered unique to human beings ‘separate us from the rest of the animal kingdom’ through some kind of divine gift, when in fact they can be explained in terms of evolutionary and socialising processes. This generalizability of CAS with regards to language makes it a very powerful model for linguists. In this paper, I will discuss the ways in which language is a CAS. I will begin by looking at some examples of CAS and discuss the general characteristics of a CAS. Then I will look at how language is a CAS. Finally, I will discuss the implications of CAS for language teaching and research.

What is a CAS?

Larsen-Freeman and Cameron (2008, p. 26) use the following definitions of systems and complex (adaptive) systems, respectively: “A system has elements that

interact to form a connected whole”. “A complex system is a system with different types of elements, usually in large numbers, which connect and interact in different and changing ways”. The term complex adaptive system has the same meaning as complex system, but adaptive is added in order to emphasise the ability of the system to change to suit environmental factors. In a CAS there are agents, which are the various individual elements that make up the system, and processes, which are the actions or interactions performed by these agents. These agents and processes can themselves be CAS.

This notion that systems within a CAS are connected means that another defining feature of a CAS is that it is an open system, meaning that it can be influenced by agents or processes from outside. These outside influences can either assimilate to the system, or they can bring about a greater or lesser degree of change to the system. This inherent instability means that they are constantly evolving, and often on the edge of chaos. Chaos refers to an area of complexity theory that investigates the instability that is inherent in CAS, such systems are referred to as non-linear dynamical systems. The term chaos in this sense does not refer to a state of anarchy or disorder, but rather to the unpredictability that can occur in some systems.

Examples of CAS

Ecosystems were some of the first complex adaptive systems to be studied. Since Darwin published *The Origin of Species* (1859) providing the foundation of evolutionary biology, our understanding of natural systems has developed significantly. As we built up a picture of the complexity of biological systems, the general principals were found to be applicable to other natural phenomena (such as; astronomy, geology, etc.) and eventually to human systems (such as; economies,

traffic networks, etc.). In this section, I will briefly introduce a few concrete examples from the above systems, and then discuss the common characteristics that make them CAS. Firstly, I will describe two natural CAS (an ecosystem and a solar system), and then two manmade ones (an economy and a traffic network).¹

An ecosystem

An ecosystem is a local environment in which various flora and fauna live together in mutually dependent relationships. For example, in a small wood, there will be trees and other plants that live on the nutrients they get from decaying organic matter, which is being broken down by fungi and bacteria. These are eaten by herbivorous insects and animals, which are eaten by various predators, which in turn die, decay, and are consumed by lower orders in the food chain. This cycle of life, if left undisturbed, will reach a kind of equilibrium in which the numbers of each species will not exceed sustainable levels dictated by their available food supply. The degree of dependence varies according to the benefits each receives from the others and those that it provides. Each has a niche that it has evolved to fill within the system. When a new species enters the system to fill a niche that is already occupied, it must compete with the existing species that fills that niche. The one that has a genetic advantage, such as; a higher reproductive rate, a unique physical attribute, a special ability, etc., will become the dominant species in that niche. If a species is highly specialised for a particular niche, a sudden change in the environment can lead to extinction.

The Solar system

Our solar system is a CAS. The interactions of the physical forces acting on the Sun, planets, their moons, asteroids, and comets are finely balanced in such a way that the system maintains a relative equilibrium. The forces that would send these bodies hurtling off into space are counterbalanced by the force of gravity trapping them in fairly stable orbits. They in turn exert an influence on their parent body, for example; the tides on earth are caused by the gravitational influence of the moon. Sometimes the equilibrium is upset by collisions, which can have devastating effects, either between two objects within the system, for example, the meteorite that created the Chicxulub Crater on the Yucatan Peninsular and is believed to have caused the mass extinction of the dinosaurs at the end of the Cretaceous Period (Short, undated), or when an object from outside enters the system (for example, the Comet Shoemaker-Levy 9 that broke up before colliding with Jupiter in 1994). The solar system itself is also a part of the Milky Way Galaxy, which in turn interacts with the billions of

other galaxies in the universe.

An economy

An economy is also a CAS. Take the Japanese economy, for example, there are a very wide variety of companies, investors, consumers, and regulators who interact in various ways to achieve their respective goals. While there are laws and regulations governing the fair conduct of business (although some may choose to circumvent or break them), generally the process allows any of these agents to do business with whom they choose. Japan is also dependent on imports from and exports to other countries, because it is part of the wider global economy, which is itself a CAS. The economies of the towns and cities of Japan are themselves CAS, as are the individual companies and consumers.

A traffic network

A traffic system is, like an economy, a manmade CAS, which is regulated in order to ensure safety and the smooth flow of traffic. When the automobile was first developed, there was very little regulation, but as the technology evolved, and numbers increased, the system adapted to the need to regulate the flow of traffic. To achieve this we now have lane markings, traffic lights, laws (and police to enforce them), etc. Most individuals choose to follow these rules in their own self-interest, however, some break them by speeding, driving drunk, running red lights, etc. putting themselves and others at risk. Individual drivers are also free to choose when to drive, where to drive to, and the route they will take to get there. Generally speaking, the traffic flow is self-regulating in that drivers will try to change their planned route if a particular road is congested. At peak times such as the rush hour and public holidays, demand can exceed the capacity of the roads resulting in major traffic jams. However, once the number of cars entering the traffic system begins to reduce, the system will self-correct, and the traffic flow will return to normal levels.

Characteristics of CAS

According to Larsen-Freeman and Cameron's (2008) definition above, a complex adaptive system is a collection of different types of elements, usually in large numbers, which connect and interact in different and changing ways to form a connected whole that changes over time. The above examples all fit this description, there are various types of elements in each of the systems, such as: the flora and fauna in the ecosystem; the star, planets, and asteroids in the solar system; the companies, consumers, and regulators in the economy; and the drivers, passengers, police, and regulators in the traffic network. In complexity theory, these individual

¹ I have used examples that I hope should be common knowledge for most readers, therefore no citations are given in the text.

elements are called 'agents'. The connections and interactions between them are called 'processes'. Groups of agents or processes that share similar characteristics are known as 'types'. These agents, processes, and types can themselves be CAS. Most CAS have agents, but it is also possible to have only processes, for example a cognitive system does not have any agents.

Another important point to make about CAS is that they are open systems. The system does not exist in isolation, there is a constant flow of agents and processes entering and leaving the system as it interacts with surrounding systems. This provides the energy that the system needs to sustain itself. Migratory birds and animals are a perfect example of this. Birds that migrate hundreds, or even thousands of kilometres, from breeding grounds to winter feeding grounds sometimes carry seeds in their stomachs, which they then excrete some distance away. If the seeds germinate and reach maturity, they increase the range of that plant, and the biodiversity of the new area, whether this is a positive or negative thing depends on the impact that the plant has on its new environment. Likewise, there is a constant flow of vehicles in and out of a city's traffic system, and the strength of a country's economy is usually measured in terms of its balance of trade with other countries.

Beckner et al. (2009, pp. 14-18) describe seven characteristics of a CAS that are relevant to language. I will briefly introduce each of them using the above four examples of CAS, and then in the next section I will discuss how they relate to language.

Distributed control and collective emergence

Each agent in a CAS is able to influence the system in some way, but there is no single agent that exerts executive control. Changes in the overall system occur when a sufficient number of agents adopt it. Therefore, change occurs as a bottom-up process as opposed to a top-down one, for example; in an economy, the share price index is an indicator of the collective state of the market, so when most investors are confident and there is demand for shares, prices generally rise causing the share price index to also rise, but when confidence is low, prices will drop. As has been demonstrated on many occasions in the past it is very difficult for regulators to exercise a significant influence, let alone control, over stock markets, especially during chaotic periods of irrational behaviour, such as bubbles or crashes.

Intrinsic diversity

An important characteristic of a CAS is that it consists of a variety of types of agents and processes. In the woodland ecosystem described above, there would likely be a very large number of species of fungi,

insects, spiders, reptiles, rodents, birds, browsing mammals, and predatory mammals; all living in and among, and feeding on the trees, undergrowth, leaf and other organic matter, and each other. In the case of the economy, there are also many types of agents, such as; companies, consumers, investors, regulators, stock exchanges, etc. as well as involvement by police and the justice system, and transportation and infrastructure. It is this diversity that gives the system its complexity. Each has its own niche in the system, and the loss of any one of them will have an impact on the system to a greater or lesser degree. So, for example, if a particular predator were to suddenly disappear from the food chain for some reason, the species that it usually preys on will suddenly increase in numbers because their breeding patterns are based a certain rate of predation, this will in turn lead to increased competition for resources. The system will eventually return to a state of equilibrium through a reduction in the birth rate, starvation, migration, a different species taking over the role of predator, or any combination of these processes.

Perpetual dynamics

A CAS is constantly in a state of flux. In an ecosystem, new individuals are born and others die, some migrate to or from the system either permanently or temporarily, and some struggle while others thrive. There are also external factors, such as; climate change, seasonal (or unseasonal) weather patterns, pollution, etc. that can also affect change; for example, if a species' breeding cycle is predicated on the occurrence of a rainy season, a delay or failure in the arrival of the rains could have a devastating effect on their population. The solar system is also in constant motion, if the planets did not orbit the Sun, its gravitational field would draw them into it. This motion consequently carries the risk of collisions, especially between asteroids, the debris of which often impacts planets as evidenced by the the large number of impact craters on many of the planets and moons (Short, undated), including the Chicxulub impact event, which is generally believed to have been the cause of the mass extinction event at the end of the Cretaceous Period. In economics, if the flow of money, labour, and goods and services were to stop the whole system would cease to exist. Likewise, a traffic network is by its very nature about movement.

Adaptation through amplification and competition of factors

A CAS is constantly changing and the system and its various agents have to adapt to the changing situation. In biology, one mechanism of change is mutation. Sexual reproduction causes constant minor changes in the genetic structure creating mutations, which can have a positive or negative effect on that individual. If it is negative, the chances of the individual surviving to maturity and reproducing are lower, thus ending that

particular mutation. Conversely, if it is positive, the individual will thrive and pass on the genetic trait to its offspring, who will develop it further. This notion of 'survival of the fittest' is one of the cornerstones of Darwinian evolutionary theory.

A recent example of this is the near economic collapse that occurred in the U.S. economy. In the United States, there were a lot of regulations put in place in the 1930's as a result of the hard economic lessons learned from the Great Depression. These strong regulations were designed to prevent the boom and bust economics characteristic of the times prior to the depression. However, over time, as many of the lessons were forgotten, politicians under pressure from industry lobby groups gradually watered down those regulations. This deregulation combined with overconfidence in the market, high levels of personal debt due to the easy availability of credit, and a strong general desire among Americans (and the rest of the developed world) for home ownership, lead to the evolution of a situation where mortgages could be packaged together and traded on the derivatives market. Once the markets realised that many of these mortgages had been extended to low-income people who could not afford to repay them by banks that no longer had to carry the risk associated with such mortgages, the bottom fell out of the derivatives market and their value plummeted, sparking the current worldwide economic recession, and requiring massive government bailouts to avoid a repeat of the Great Depression. It was the cumulative effects of these various factors, each in its own right comparatively small, and occurring gradually over time, that took the global economy close to the brink of collapse.

Nonlinearity and phase transitions

Change in a CAS is nonlinear, meaning that over time even a very small change within part, or parts, of the system can have a major effect on the system as a whole. In other words, there is no correlation between the sizes of the cause and its effect. The pressure for change builds up over time until it reaches a critical level, and then it is suddenly released. As we saw in the example of the current economic crisis, the cumulative effects of relatively minor changes over time nearly caused a collapse of the whole system. The gradual erosion of the economic regulations, and the shift in attitudes towards debt occurred over three-quarters of a century, however, the resulting crisis occurred over a relatively short period. This kind of sudden change is known as a phase transition.

Sensitivity to and dependence on network structure

The network structure of a CAS is very important. Furthermore, the connections between the various agents in the network are not random. Research into

network structure has shown that they are governed by robust organising principles (Albert & Barabási, 2002) and that their internal structure and connectivity can affect system dynamics (Newman, Barabási, & Watts, 2006). As we have seen above in the ecosystem a change that affects one species will also have a knock-on effect on the species above and below it in the food chain. Similarly, when we drive, we are constantly reacting to other road users, whether it is stopping at traffic lights to allow others to cross an intersection, changing lanes to overtake a slow driver, or waiting for a parking spot to open up. Furthermore, not only do we have to drive in a safe manner, but we have to rely on other road users to do the same, and be prepared for the times when they don't.

Change is local

As we saw above, a CAS is not controlled by any particular agent, instead change emerges from the bottom-up. "Complexity arises in systems via incremental changes, based on locally available resources, rather than via top-down direction or deliberate movement toward some goal" (Beckner, et al., 2009, p. 17). CAS's are constantly evolving and it is the individual agents who drive the mechanism of that change. A school of fish or a flock of birds may appear to move as if under some form of control, however, its movement is the collective accumulation of reactions of individuals to stimuli in the environment, such as; the movements of others, attacks by predators, or obstacles. In a study of starling flocks, Ballerini et al. (2008) found that each bird modified its position, relative to the six or seven birds directly surrounding it, no matter how close or how far away those birds were.

Similarly, an individual animal that receives a genetic trait that gives it a competitive advantage is more likely to thrive and mate, passing on that genetic advantage to its descendants, who will mate distributing it among other members of the species, some of whom will amplify it while others introduce further traits, eventually leading to sub-speciation. Competition is not limited to species. Companies carry out research and development, and market research in order to produce goods and services that will give them a competitive advantage in the market. For example, in the computer market there was only weak demand for tablet computers until Apple Inc. launched the iPad, they simultaneously created a new product, a niche for it to fill, and a demand for their product. To date, no competitor has been able to make significant progress in this new niche market.

Summary

In summary, a CAS is an open system made up of a variety of agents and processes that may be CAS's themselves. These agents and processes interact in

complex ways. The individuals in the system are able to exert varying degrees of influence on the system, but this influence is generally limited to their local surroundings, so no single entity has control of the system, instead change emerges from the bottom-up. A CAS is constantly changing, and it evolves over time in a nonlinear fashion, so that a small change can have consequences way out of proportion to its initial circumstances. The system often swings from periods of relative stability to periods of rapid change.

How is language a CAS?

In this section, I will argue that, like the above examples, language is also a CAS. Firstly, I will briefly introduce a common metaphor for language. Next, I will define three different levels of language to be used in the discussion to follow. Then, I will discuss how each of the above characteristics of CAS can be applied to language.

It is quite common for people to think of difficult concepts in terms of metaphors (Lakoff & Johnson, 1980). In the case of language, it is often seen as a living thing. We talk of 'language extinction' when a language is no longer used, and such a language is referred to as a 'dead language'. This metaphor is possible because a language has many things in common with living things. As a rule, we do not describe a language as living except to contrast it with one that is considered to be dead. For example, Latin is often described as a dead language because there are no longer any communities in which it is spoken as a first language, but it is a testament to the power and prestige of the Roman Empire that it still known, and taught in schools and universities. After the fall of Rome, it continued for a long time as the language of the Roman Catholic church, and of scholarship in Europe, albeit, only as a second language. Furthermore, its descendants, the modern Romance languages, are still thriving, supporting the notion that languages also evolve, further illustrated by the fact that Old English is mostly incomprehensible to speakers of Modern English. They also have different varieties suited to particular conditions, such as; regional dialects, prestige dialects, technical or specialist language, etc. The fact that language can be described in terms of living things, in itself, is grounds to view language as a CAS.

Three levels of language

In the following discussion, I will use 'language' as a generic term. I will also distinguish between three different categories of language; official languages, sociolects, and idiolects.

Official language

If we were to ask someone what language they speak,

they will most likely give the name of the official language of their country of origin. These are languages that have become, by various means, the language of government of a particular nation state, and are also the language of administration, law, commerce, education, mass media, etc. Usually, they are the first language spoken by the majority of its citizens, although in some cases it might be that of a privileged minority. The statement "A language is a dialect with an army and navy" (commonly attributed to the linguist, Max Weinreich) quite poignantly expresses the true nature of an official language, it is a political construct rather than a social one.

Sociolect

Louwerse (2004, p. 207) defines a sociolect as "similarities in the language use of a community of individuals." In other words, it is the collective language of each community. It is spoken by a group of people living in the same place or having a particular characteristic in common. These could be based on factors like: regional variations, class distinctions, the work place, or groups with common interests, such as sports players, hobbyists, etc.

Idiolect

Louwerse (2004, p. 207) defines an idiolect as "similarities in the language use of an individual." An idiolect is all of the languages and sociolects that an individual uses, or is capable of using. I have used the plural here because even a monolingual speaker of an official language is in fact a speaker of many sociolects. We all (with very rare exceptions) participate in various communities, such as; family, close friends, acquaintances, colleagues, interest groups, etc., and we code switch to suit the sociolect we share with our interlocutors, for example, we speak differently to close friends than to colleagues in the workplace where we might use a more formal tone with more work-related jargon.

Characteristics of language as a CAS

In this section, I will discuss these points in more detail using the characteristics of a CAS from the previous section.

Distributed control and collective emergence

A CAS can itself be a part of, or consist of, other CAS. So, collections of individuals with their own idiolects interact in dynamic ways to form mutually intelligible sociolects. Languages change over time as the interactions of individual users bring about subtle changes in the language as they attempt to assimilate to the different kinds of social situations and relationships in which they find themselves. For example, after the Norman invasion of England, even though the Anglo-Norman nobility spoke French, the common people

continued to speak English, this eventually filtered up and became the language of the court. Another example is the difficulties that the Académie Française has had trying to regulate the use of loanwords in French (Crystal, 1997, p. 4).

In a CAS, change is an emergent phenomenon, Emergentism is seen as highly compatible with CAS (Ellis & Larsen-Freeman, 2009). Proponents of emergentism see grammar and vocabulary as being derived from chunks of language, known as formulaic sequences. A formulaic sequence is “a sequence, continuous or discontinuous, of words or other elements, which is, or appears to be, prefabricated: that is, stored and retrieved whole from memory at the time of use, rather than being subject to generation or analysis by the language grammar” (Wray, 2002, p. 9). In an emergentist view formulaic sequences are first learned as unanalysed chunks, which are later deconstructed into their component parts, and in turn become available for generative use. N Ellis (1996) describes emergentism as a network of connected units that accumulate over time creating a complex system built upon the foundation of phonological units. “Taken together, these studies suggest that in both L1 and L2, lexical items are first represented as ordered phonological strings, then there is a focus on their collocations and their sequential probabilities in word strings, and only later are these patterns of occurrence analyzed to allow syntactic and semantic classification” (1996, p. 94).

This is based on work by Hakuta (1974, 1976) who found in a study of a five-year-old Japanese child learning English as a second language, that she would use a particular formula correctly at first, but then would later make mistakes before beginning to use it correctly again. This suggests that the natural developmental order is unanalysed chunks, which are then parsed into their component parts and tried out in different contexts until the learner builds up a picture of when the items can or cannot be used. Wong-Fillmore (1976) came to a similar conclusion in her study of five Spanish-speaking children learning L2 English, claiming that formulaic sequences “evolve directly into creative language” (1976, p. 640). Bohn (1986), using data from Wode (1981) of the acquisition of L2 English by four German-speaking children, argued that Wong-Fillmore used too broad a definition of formulaic language and that his own results showed that “formulas and frame structures do not contribute to early L2 syntactic development” (1986, p. 185). However, he does concede that it “may play some part in the acquisition of more complex structural areas” (1986, p. 185). Weinert (1995) defended Wong-Fillmore, describing her data as “very convincing” and adding that “it is possible that smaller formulaic chunks also played a role in the Wode data”

(1995, p. 189)

Bybee (2006) explains this process in terms of usage-based grammar, whereby, “grammar is the cognitive organisation of one’s experience with language” (2006, p. 711). Hopper (1998) describes the emergentist stance whereby “grammar is not to be seen as the source of regularity, but instead as what results when formulas are rearranged, or dismantled and reassembled, in different ways” (1998, p. 167). These emergentist accounts of language learning strongly suggest that grammar is derived from frequently occurring language patterns, rather than the other way around.

Intrinsic diversity

There are an estimated 5,000 to 6,000 languages in the world (Crystal, 1997). If we include dialects, this figure will be much larger. Some languages have strict word order such as SVO (English) and SOV (Japanese), others are more flexible (Old English, Latin). Some are stress timed (English), and others are syllable timed (Japanese, NZ Maori). There is no single language that is representative of all languages. Similarly, there is no person who can be said to be representative of all speakers, in general or for specific languages. “Each idiolect is the product of the individual’s unique exposure and experiences of language use” (Beckner, et al., 2009).

Perpetual dynamics

Language is in a constant state of change both at the individual and social level, as knowledge and experience change and shape perceptions of the world around the person and the community. The available evidence of human evolution suggests that the proto-humans were apes that were cut off from the jungles of East Africa by the formation of the Great Rift and forced to live on the dry savannah that formed on the western side. Like most apes, human beings are highly social, and living in such close-knit groups it is necessary to be able to communicate specific wants and needs. In the close confines of the jungle with an abundant food supply, it would have been possible to do this using touch, gesture, and simple grunts, as is typical of other apes. However, on the savannah, the distances involved and scarcity of food required a more sophisticated means of communication. Over time, the simple grunts became more sophisticated and as the phonological possibilities expanded, so did the vocabulary. Likewise, as the societies and technology expanded and became more sophisticated, the vocabulary needed to describe them also expanded, accordingly. There was also a shift in language use from more concrete, immediate matters to more abstract, philosophical ideas. The important thing to remember here is that this evolution occurred over several millions of years.

It seems counterintuitive that of all natural phenomena, language would be the only one that does not conform to the regular patterns of development found in nature. Language theories that posit that language is somehow a genetically imprinted trait, i.e. innatist views which claim that we come pre-programmed with some kind of a universal grammar requiring a language acquisition device to fine-tune it to a specific language, ignore the simple fact that a child learning their first language has the advantage of knowing that it can be done because they see people around them doing it. For example; my 7-year-old son recently learned to snap his fingers. He practiced for three or four weeks before he was able to do it consistently. He was able to do this because of his persistence, but this was motivated by the knowledge that it was possible because he had seen me do it and asked me to show him how it is done. If he had not had that knowledge, he would not have spent so much time trying to master a skill that to him would not have seemed possible.

Adaptation through amplification and competition of factors

Time is an important factor in complexity theory. Like many other natural phenomena, language evolves over time. The term 'survival of the fittest' can also be applied to language, where 'the fittest' refers to those forms that are easily used or remembered and are encountered often. It has been shown in many studies that people are very sensitive to the frequency of occurrence of words and structures (Nation, 2001). As language users interact with others in an attempt to assimilate to the particular speech community, they gradually develop a picture of frequently occurring items and how and when they can or cannot be used. This evolutionary process can be seen in both idiolects and sociolects. The evolution of an idiolect is a life-long process that develops through social interaction with other members of speech communities. This development² of the idiolect can be seen as adaptation through amplification and competition of various features of the language as new features are incorporated into the system and cause restructuring. Similarly, the learning of another language can be seen as assimilation to a different speech community through the addition of new features to the learner's language system that they use selectively depending on the interlocutor. I remember being very impressed at a party when a Singaporean friend was able to switch freely during the same conversation between Chinese, English, and Japanese depending on who she was addressing at the time. In fact, this something that all of us do, but at the level of the sociolect rather than the language.

The elements within the system compete for their place in the system, and if one element expands in its use or meaning, or is introduced into other domains, other element in turn have to adapt to the new situation or disappear, i.e. the Old English word 'beorn' fell out of use in English with the introduction of the word 'baby' some time around the 14th century, but the older word was retained in Scots.

Nonlinearity and phase transitions

The system remains in a state of equilibrium for a period until something triggers a change, it then enters a transition phase before settling in to a new equilibrium. If we look, for example, at the history of English, there are three distinct periods; Old, Middle, and Modern English. The transition from Old English to Middle English occurred as a result of the Norman invasion in 1066 AD, because French was the language of the Anglo-Norman nobility who displaced the Anglo-Saxon one. It is estimated that about 10,000 French words were introduced into the English language during the subsequent 200 years (McCrum, Cran, & MacNeil, 1993). The next big transition from Middle English to Modern English cannot be traced back to one historical event the way that the first can. It occurred as a result of several social and technological changes, they include, the introduction of the printing press, popular education, increased means of communication, increased knowledge through scientific enquiry and a new self-consciousness about language (Baugh & Cable, 1993). This coincided with the Great Vowel Shift and the Renaissance. The first transition is the result of a sudden and violent change in the political landscape of England, which is reflected in the language. The other is more subtle, and occurred over a longer period and included the great vowel shift, but is no less profound in its effect on the language.

Sensitivity to and dependence on network structure

One of the key functions of language is to allow us to communicate with others around us. As mentioned above, it is primarily a social activity. Sociocultural theory gives social interaction a central role in language development and use (Lantolf, 2000, 2006; Vygotsky, 1978). Our social contacts do not occur at random, instead they include people like; family, friends, acquaintances, co-workers, etc. This is a typical network structure, in fact, we often refer to these people as our social network. It is through contact with this social network that we acquire language, and we in turn are able to influence those around us. Furthermore, language requires cognitive ability, and when we look at the structure of the brain, we see that it also has a

² Larsen-Freeman and Cameron (2008) prefer the term language development rather than acquisition because the former implies a complete system that changes over time, whereas, the latter implies the accumulation of discrete points to make a complete collection.

network structure of neurons connected by synapses. This structure is an integral part of our acquisition of knowledge in general and language specifically (Christiansen & Chater, 2008). Neurolinguists are beginning to understand some of the processes involved in children's first language acquisition, and they support the sociocultural view (Kuhl, 2010).

Change is local

Sociocultural theory asserts that a sociolect is the dynamic accumulation of the interactions of individual idiolects, and that this social interaction causes both to develop. In other words, an idiolect is an accumulation of that individual's experiences of interacting with others, which in turn affects the others' idiolects, and cumulatively they can affect the sociolects and official language in a bottom-up process. For most people, their influence on the language is very minor because of the limited size of our social networks, however there are those who are able to reach a wider audience, and thus can exercise some influence, such as, celebrities, political figures, literary figures, etc. However, when a new word or phrase is coined, and if it catches on in the initiating network, the members of that network will pass it on to other members of their own networks, who in turn spread it on through theirs. This bottom-up process is the basic mechanism by which change occurs in the language system.

Summary

In summary, we have seen that language is an open system made up of a wide variety of idiolects and sociolects that interact through process of socialisation, and are CAS's themselves. Language users can exert varying degrees of influence on the system, but this influence is generally limited to their local surroundings. Attempts to control language systems generally fail, instead change emerges from the bottom-up. Languages are constantly changing, and evolving over time in a nonlinear fashion due to social, political, technological, philosophical, and other influences, and these can cause periods of relative stability to periods of rapid change.

Implications for teaching and research

This way of looking at language has implications for teachers and researchers. In particular, it means taking a more holistic approach to language studies, and rather than try to isolate particular features that we want to learn about, we should embrace this complexity for the richer picture that it can give us.

Teaching

From a CAS perspective, the development of a second language is a similar process to that of a first language. However, there is a fundamental difference in the contexts in which they occur, and this difference in

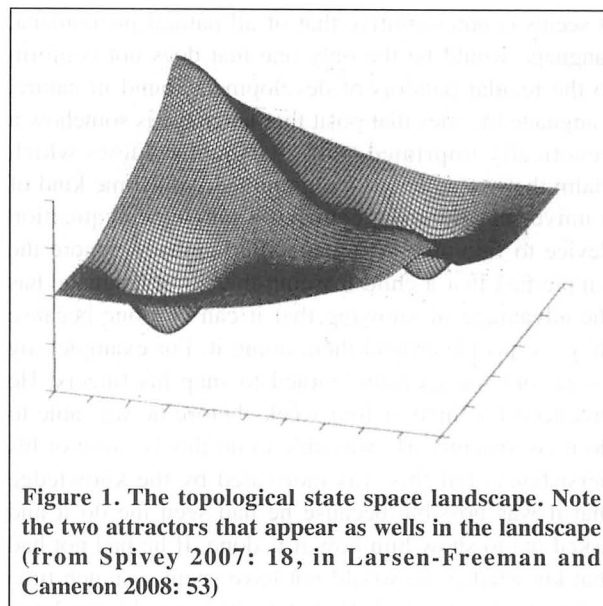


Figure 1. The topological state space landscape. Note the two attractors that appear as wells in the landscape (from Spivey 2007: 18, in Larsen-Freeman and Cameron 2008: 53)

starting points can have a major effect on outcomes. In the case of a bilingual child, the two languages develop roughly in parallel with their general cognitive abilities, as the child interacts with members of the two language communities. The degree of bilingualism depends on the amount and quality of the interaction with each language. On the other hand, in the case of an older individual learning a second language, this cognitive and first language development has already reached a more advanced state, which can have the effect of resisting change. In CAS, this advanced state is described as having reached an attractor state.

An attractor is a tendency to settle into regular patterns of behaviour. A useful metaphor to understand CAS is that of a landscape with hills and valleys shaped by the various factors affecting the system. In the case of language, these factors include social, psychological, physiological, cognitive, etc. Figure 1 illustrates an example of such a landscape, which is known as the state space. "A state space or phase space represents the 'landscape of possibilities' of a system, and, as it changes and adapts over time, the system moves through this landscape" (Larsen-Freeman and Cameron, 2008, 49). "A phase space is a state space with at least one dimension relating to change over time" (Larsen-Freeman and Cameron, 2008, 47). The system follows a trajectory across this state space. As with any kind of movement across uneven terrain, moving downhill requires less effort than moving uphill, and the steeper or higher the slope, the greater the amount of energy that is required to overcome it.

If we think of a preferred teaching style as one of the valleys, or attractors, then those aspects that are readily changed will be shallower than more entrenched aspects. Likewise, those desired behaviours that are difficult to adopt will be higher and may appear as hills

in the state space landscape, in which case they will require more energy to attain and maintain. For example, it is a common complaint of teachers in Japan that their students can be quite reticent. This can affect the way that they teach, which in turn affects the way that students respond to the class. This can lead to a set of expectations on the part of both the teacher and students that favour a more teacher centred style. Such a class can be said to have descended into an attractor, in this case, a negative behaviour that is less conducive to interaction, and a concomitant lack of progress in speaking ability on the part of students. In order to break this cycle, it is necessary for some kind of force to provide the impetus to break out of the cycle. One such impetus could be participation in a study abroad program, which would force students out of their comfort zones and to interact with native speakers in order to satisfy their day-to-day needs. In my experience, even fairly short study abroad programs can have a dramatic effect on a student's willingness to interact in English. This temporary phase state outside of the student's comfort zone could be considered to be one of the hills, from which they soon return, but hopefully not back to the original attractor state.

A CAS based explanation of the place of instruction in L2 development is that it can provide the learner with a controlled environment in which their attention can be drawn to the forms of the language that they might not otherwise notice. Larsen-Freeman (2006) conducted a time-series study of five Chinese learners of English from a CAS perspective. At six week intervals, she collected samples of writing in which they told the same story each time, and oral samples of the same story told after a three day delay. Using a combination of quantitative and qualitative methods, she found evidence of; stable patterns and variation, progress and regress, a variegated set of language patterns, waxing and waning of such patterns, intra-individual and inter-individual variation over time, nonlinearity, competition between subsystems, and a lack of linguistic rigor mortis. She claimed that these are evidence of how a CAS approach can give a deeper understanding of learner development. Larsen-Freeman concluded that "Patterns in interlanguage emerge from the complexity and frequency in the L1 and L2 and their energetic status, shaped by individual learner orientations and contextual variables" (2006, p. 615).

Research

Complexity theory seeks to give a more complete explanation of the complex interaction of all of the subsystems of language. In a CAS research paradigm, context is an essential component of any study. While certain aspects of language can be the focus, they cannot be studied in isolation. This holistic approach to research is in opposition to the psychometric approach

where extraneous variables are to be isolated and controlled. In a CAS approach, these variables are seen as providing a more complete picture of the data.

I think that one of the main advantages of a CAS approach to the study of language is that it takes a much wider view of language. By not filtering out so-called extraneous variables, it offers a much richer view of language. This richer view requires researchers to observe language in less controlled settings, and over a longer period of time. For this reason, proponents of CAS prefer qualitative or mixed methods studies of language.

Conclusion

Human beings are highly social, and the need for social interaction is a strong driving force behind many of the things we do. As we saw in the above examples of CAS, many human activities are highly complex. I have argued that language is also a CAS, in fact, I think that it is actually the most complex of all human activities. Beckner et al. summarise the concept of language as a CAS as follows;

Language as a CAS involves the following key features: The system consists of multiple agents in speech communities interacting with one another. The system is adaptive; that is, speakers' behaviour is based on their past interactions, and current and past interactions together feed forward into future behaviour. A speaker's behaviour is the consequence of competing factors ranging from perceptual constraints to social motivations. The structures of language emerge from interrelated patterns of experience, social interaction, and cognitive mechanisms. (Beckner, et al., 2009, pp 1-2)

Lantolf (2006) argues that CAS, emergentism, and dynamic systems are very compatible with sociocultural theory in most areas, however, he questions whether the role of environment in CAS is as a resource that supports cognitive development or as the primary source of it. However, I think that the above quote from Beckner et al. about past interactions, while not doing so specifically, addresses this issue. While some knowledge is discovered through personal experience, the vast majority of an individual's knowledge, both linguistic and non-linguistic, is learned from others, whether they be family, friends, the media, or teachers. I think that with the exception of innatist views of language, complexity theory is compatible with many fields in linguistics, and it offers them new and interesting ways to look at language.

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