Art complexity and Technology: their interaction in emergence

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"'Kovalevsky's top' and the Theatre of Complexity"

Most of you know what you understand by the term 'complexity', but for me it is a collection of methods and a way of looking at systems to see how collective properties can give rise to emergent behaviours. It also has its roots in dynamical systems and a lot of techniques for analysing these can be used. Today we are looking at the connection with art and some of the talks so far have looked at structures and how we can use complex systems to generate certain structures, which then form the basis of aesthetic experience. This is one possibility, but in my talk I'm going to look at another aspect of art which has to do with making representations. I will explain in a moment what I mean by representation because the word has many meanings. If we look at some examples of modern art they may not have an aesthetic quality, but that is not their point at all. There is another aspect of art which to artists is much more important than the aesthetics and I call it representation making.

I will start with children. Here is drawing by a four year old child and you may have a number of ideas about what it represents. You may think it's a garden or a kitchen but it actually it is a bus. You can see the bus has many wheels and many windows and it has a tiny driver sitting in a little box at the front. He's very small compared to the driver who goes around asking for your ticket. This representation is about meaning. It's about aspects of the world that are important for the person that is interacting with it. For this child the bus is huge so the whole page is filled with it and you can see the conductor's hand out asking for your ticket, because if you don't have your ticket you're in deep trouble. And the windows are bigger in the front because it's a double-decker British bus and it's exciting to sit on top at the front, because it's exciting to move above the street like that.

So that's the first part; picking out meanings. Also note the perspectives. You can see, for example, that for the conductor there is a perspective from the side and a perspective from the top. The bus is also seen from the side and seen from the top. So you have multiple perspectives occurring together which are expressions of meaning. What is incredible about children is what we call creativity; finding new ways of expressing meanings as in the case of the wheels. There's a bit of glamorising here because the drawing has so many wheels you cannot count, them just as the number of windows says something as well.

This kind of representation-making comes very naturally to children, but unfortunately our education system is designed to stamp it out and by the age of say twelve, children don't do it any more unless they become artists. Look at this

picture of a horse by a three year old. A horse has four legs as you know; two legs at the front and two at the back. So how can you draw it so it can have four legs? Well you turn the paper over and draw the two on the other side and then if you hold it up to the light you have a beautiful 3D horse. For me the roots of art are that. The form is part of it but it's not the main thing.

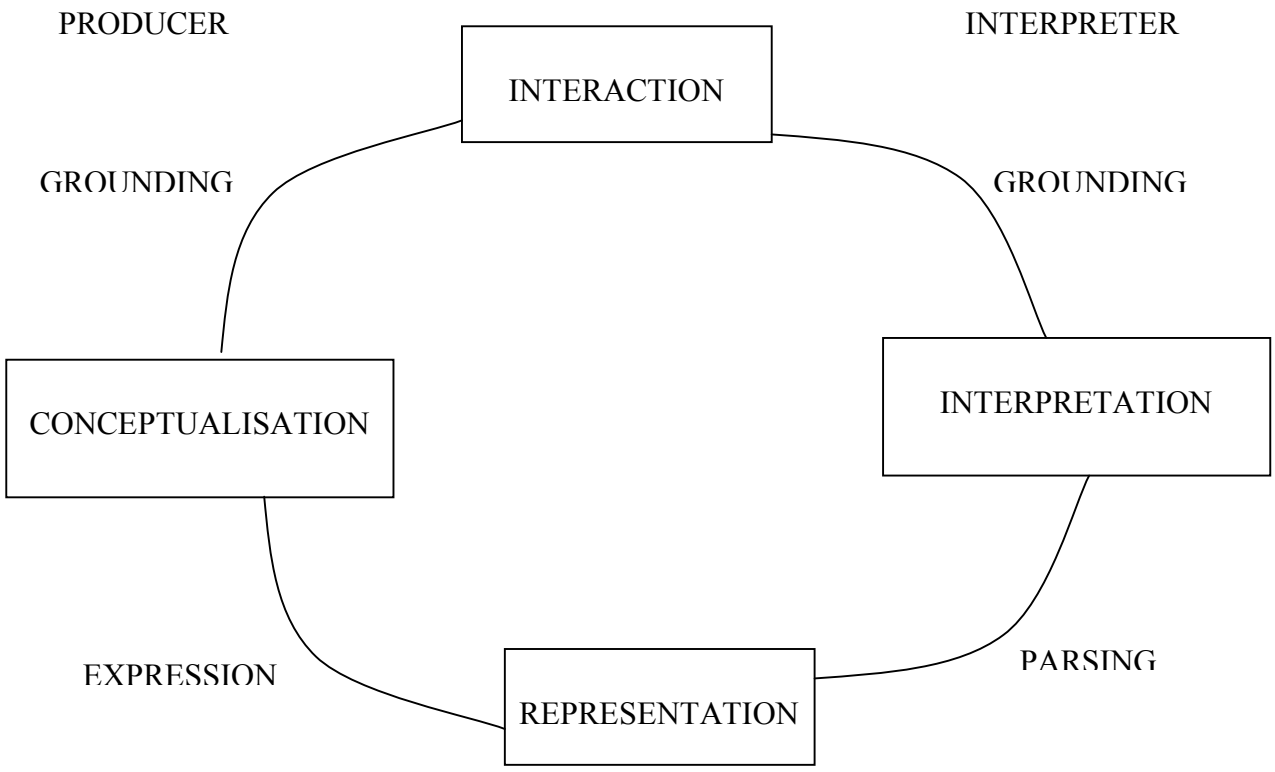
I can show you another picture of horses and whilst it may have some aesthetic qualities, it is important to note there is one horse here and another there, in a different perspective; just on top of it and sometimes the lines of one are reused in the other. This drawing dates from 40,000 years ago. Here are others from the Lascaux caves. There is a bison and it is a representation of the kind I have been talking about. It's not just a drawing of a bison. There is a spear which goes through it, there's a person lying near it, and the head of this person is a bird, and there's also a totem which is birdlike, and another spear. Of course there are undoubtedly meanings we don't understand anymore.

If you look at a Picasso drawing and just look at it from one perspective, you might say this man is deranged, but putting in all these perspectives is a way to capture or bring out meaning in a woman, or women, lying on a bed. If you take it literally you just don't get it, so it's a sort of puzzle that Picasso has created for us. You can look at it for maybe half an hour, seeing other body parts and perhaps making more sense of what is being shown.

If you want to understand cognition then this representation-making business is actually what makes us human. If you're looking for a unique characteristic then I believe this representation-making is actually the key to understanding our humanity. The producer is grounded in reality and making meaning by interacting with it, and in order to make a representation the producer has to conceptualise and select the meanings that he or she wants to convey. And there is always an interpreter. It's a coupled system of co-evolution because the interpreter has to ground the interpretation back into the world in order to understand it. So there's not just a single meaning, but a web and because we don't have any telepathic way to know the meanings the interpreter has to impose them and reconstruct, by projecting them back onto the representation. What makes this so exciting when we start talking about good art, is that it offers an infinite source of possible interpretations and experiences; meanings that different people may discern when exposed to it.

Now you may wonder why we do this and why artists do it more than most. The prime reason for representation is for communication. We create a representation and we present it to somebody else in an attempt to communicate. Language can be seen as a collective repertoire of representational patterns that have been agreed upon and are shared. This is where I believe ideas on complexity and art or language come together. All are used as a representational medium. When I say "the bottle" and everyone agrees on the bottle, we share some of this conceptualisation of the world and common way to name things, so that we can communicate. It is the sharing that enables us to see language as a complex system.

Producer/interpreter cycle:



Another reason why we make representations is in the process of self development and when children make these drawings often the parents just say: "Oh this is nice". They don't make any attempt to understand the drawing, which is sad because they could learn a lot about the child and his or her interacting with the world. The child is going through a process of self development; trying to make representations and bringing out meanings that he or she is trying to cope with. What artists are doing is a kind of self development; selection of meaning and selection of perspectives as a way to advance. Representation-making can be used and is used, by older cultures, as a way of breaking through existing states of order as, for example, in a carnival where people dress up as something else and the social order is temporarily changed. It's a way of discovering new relationships.

One of the ways in which I have been interacting with artists has been looking at the possibilities of simulating representation – making with computers

and robots. If we can train robots to make their own representations it raises interesting possibilities for cognition theory and I want to talk about the results of some collaborations.

The first was what I call a 'talking heads' experiment which consists of two cameras that can move around as 'pan tilt' cameras, so they are like very basic robots. And then we have 'agents' that can look at the world and play language with each other. This is a kind of representation-making, because the speaker has to select an object from the world and invent a word for it. The listener then has to guess the meaning intended and use that meaning to refer back to the object.

The experiment was carried out in museums in Antwerp, London, Paris and Cambridge with connections via the Internet. This gave the possibility of different 'agents' that could play the different word games. After a while we had three thousand 'agents' inventing a language to talk about objects. It was a complex adaptive system in that agents used representation-making to create a language which emerged because of the interaction. We, as the researchers in the experiment, were able to track coherence arising in the system due to the resolution of ambiguities. The process could therefore be studied in much the same way as ecology or social ecosystems.

Another experiment was done with the artist Olaf Ulerisson, who created The Sun installation at Tate Modern. We did an experiment called 'look into the box' in which a person looks into a box and a camera takes a picture of the person's eye. We then had 'agents' talking about the characteristics of the eye in the same way as the first series of investigations.

The Japanese artist Matubani has made art installations which he uses as metaphors. In his new creation he uses a tank of petroleum jelly heated to a liquid which solidifies as it cools to around 25 – 30^{o}C. As it solidifies, sheets of petroleum jelly form and dissolve again, manifesting the change of states that occur in complex systems. When he put a tank of it on a whaling boat off the Japanese coast it was reminiscent of oozing whale blubber. It's another example of representation-making going deeper and giving new meanings and ways of looking at reality.

Just lately I have become involved in a theatre project which will be premiered in Avignon in France. It will take place in an old monastery and involves musicians and authors working together. It is a play inspired by a Russian mathematician called Sonya Kovalevsky who was at the centre of mathematical developments in dynamical systems towards the end of the 19th century. She also played a courageous pioneering role in giving women access to scientific education and research at this time. Her mentor Weierstrass, worked on calculus and new methods of integration which were applied to celestial mechanics and other physical systems.

It was also at this time that cracks began to appear in the Laplacean dream that all events in the world could become predictable by finding equations which would describe them. Kovalevsky, who contributed to these developments by

her study of the 'Kovalevsky Top', demonstrated the unpredictability of systems by investigating their non-linearity. What we're trying to do in the play is to show how new and strange events give rise to new meanings. Kovalevsky was very close to Poincaré at the time of the 'three bodies in space problem'. It was through dealing with an error in a publication that Poincaré discovered the notion of chaos which led to the language of complex dynamical systems.

A spinning top exhibits some very strange behaviour. At some point it wobbles in its spin and turns in the opposite direction. What you see is a shuddering movement which stops and then occurs again. It can also turn completely over and spin on its head. It is, of course, a chaotic system and there are three particular phases which can be mathematised. One was found by Euler which has to do with the position of the centre of gravity and the axis of symmetry. Another was found, here in Turin, by Lagrange which was the case of a top spinning like the earth and Kovalevsky found the third case. This was enormously complicated in terms of the mathematics; in fact I think very few people could actually read the paper and there are still conferences held on the Kovalevsky Top. So not only was she a physicist, but she was also involved in politics for the liberation of women and wrote novels and poetry. There was such an overwhelming amount of historical, scientific and mathematical talent combined with an incredible personality.

In the play the actors play a major role in its evolution. They are representation-makers in the way we have been considering, and have as much a say in the production as the authors. In the production, the body of the performer and the language is viewed as a medium and it is by the interaction of the performers that the meaning of the text is brought out. The players read the text again and again in order to bring it to life and there are actually three actresses who play Kovalevsky. It's a bit like a Picasso painting or a child's drawing in which you see several views at the same time and they change as in a kaleidoscope.

We can look at complex dynamical systems as the transformation from one representation space to another and the mathematics is a way of representing some of the aspects of reality. So though in physics we try to make models of reality, we are confronted by systems like the top where we cannot predict what it will do. The play reflects in some sense the dynamics of the unpredictable. The whole production is a bit like a semiotic machine and because there are inputs from different sources we cannot say, 'this is the plot'. All the participants are representation-makers.

Questioner1. Do you work interactively with the actors and put a bit of complex thinking in or is the whole thing enacting the principles by itself?

Luc: Well it is like a complex system in the sense that it is open ended, and influences are transformed into representations – actions and gestures. I don't need to put any more complex thinking into it, because it is by itself a complex system which is self organising and shows emergence.

Questioner 1: I meant are you introducing the idea of articulating some of the ideas of the actors, so that they begin to understand at a different level, that what they are doing is embodying complexity?

Luc: Yes we do that. We have had talks with historians of mathematics and mathematicians themselves. For example, we will probably bring the three body problem, and all the excitement involved in that, into the play. But it is the actors who pose the questions. They are there to interact and to bridge the gap between art and science. Okay, they might say: 'what is phase space?', and we might explain and it will all be transformed by the semiotic machine and end up somehow in the representation.

Questioner 2. I think there is a big divide between art and science because scientific theory is expressed mathematically and is objective in what it communicates. This is the opposite of what has been put forward in the talks here. I think we as scientists can reach to the other side, but the other side needs a scientific upbringing to make a bridge to us

Luc: I don't think we should underestimate the artists. We don't have to go to the mathematics to explain the idea of chaos, for example. We can explain what chaos is in a system and they can grasp the concept and ask how it can be represented in a play. So I think that the gap can be bridged, though I think that from the other side, there are a lot of scientists who are immune to art and don't understand representation-making.

Questioner3. How do you see a social system of this kind being reduced to complexity principles? Can you give us an indication of the scale?

Luc: Well, I think it only works in small settings because everybody has to be open and participating. The scientists have to be dissuaded from giving 'talks' on concepts. There are rules which can be scaled as in physical systems, but the important point is that the play is in the driving seat by asking scientists the questions.