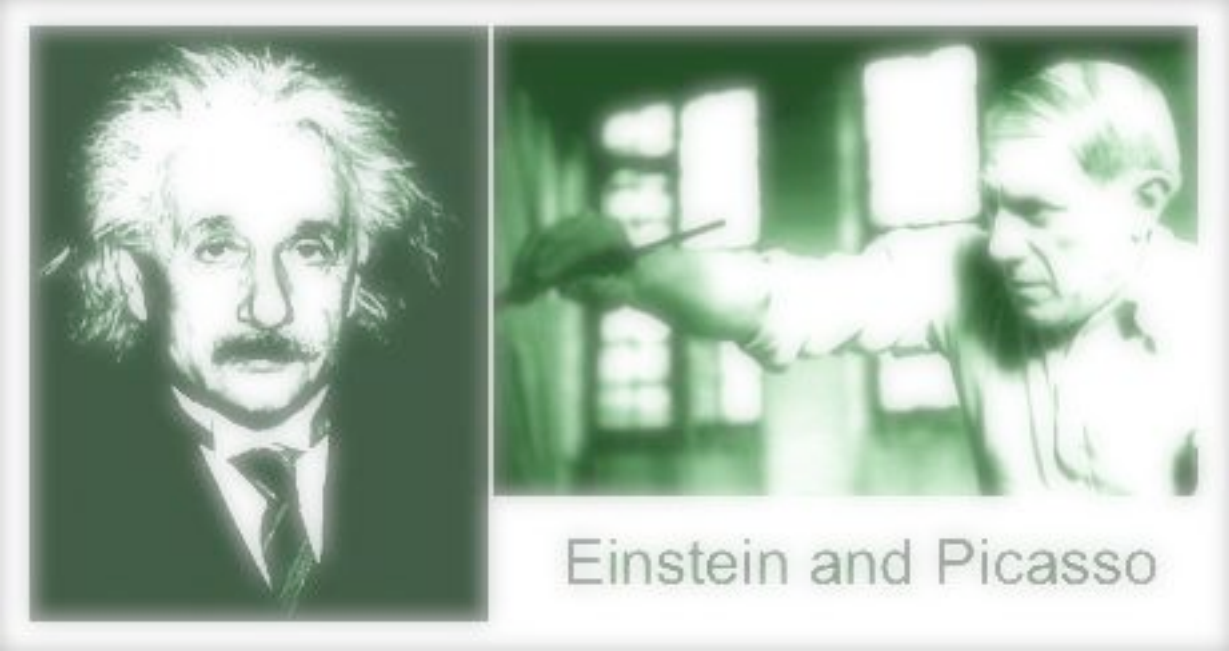


KEITH NESBITT

20th April, 2007
New England Complex Systems Institute
24 Mt Auburn Rd,
Cambridge, Boston, USA

What is the shape of an idea?

Do all ideas have the same shape?

How does your viewpoint influence your ideas?

How many viewpoints do you need to see the shape of things?

This exhibit was held at the New England Complex Systems Institute (NECSI) in Cambridge, Boston. The exhibit was held in conjunction with the sculptor, Melisa Gerber. The general theme of the exhibit was the “The Shape of an Idea”.

Many of the ideas being researched at NECSI come from the field of physics. I worked there for 12 months as a post-doc, mainly in my capacity as a computer scientist, building user interfaces and information visualisations. This exhibit was held at the end of that time in April 2007.

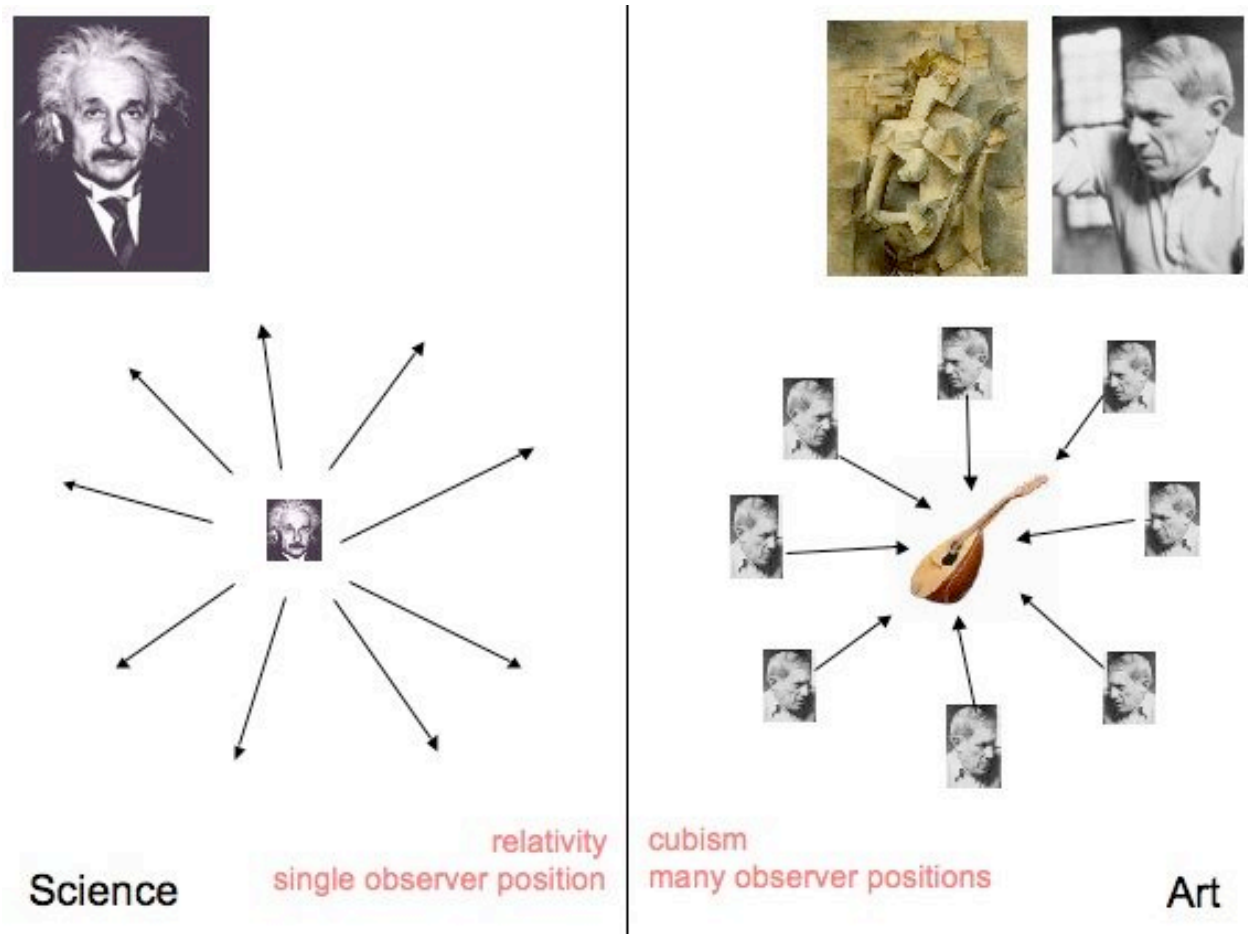
Complex Systems is an interesting field of research that is applicable to all sorts of domains, from social science, human behaviour and philosophy through to engineering, chemistry, mathematics and of course physics. However, oddly enough, it was mainly

through my painting that I was drawn into the ideas used in Complex Systems. What could be of interest to both physicists and artists?

You would think the viewpoints of Einstein and Picasso, the scientist and the artist, would be very different, almost opposite in nature. However, in some way it's these opposite viewpoints that interest me most. I like to think that all ideas can be either true or false, depending on the viewpoint. Which viewpoint is correct, the view of the artist, or the view of the scientist? Perhaps we need both viewpoints to see the real shape of things. Perhaps only with both viewpoints can we observe correctly.

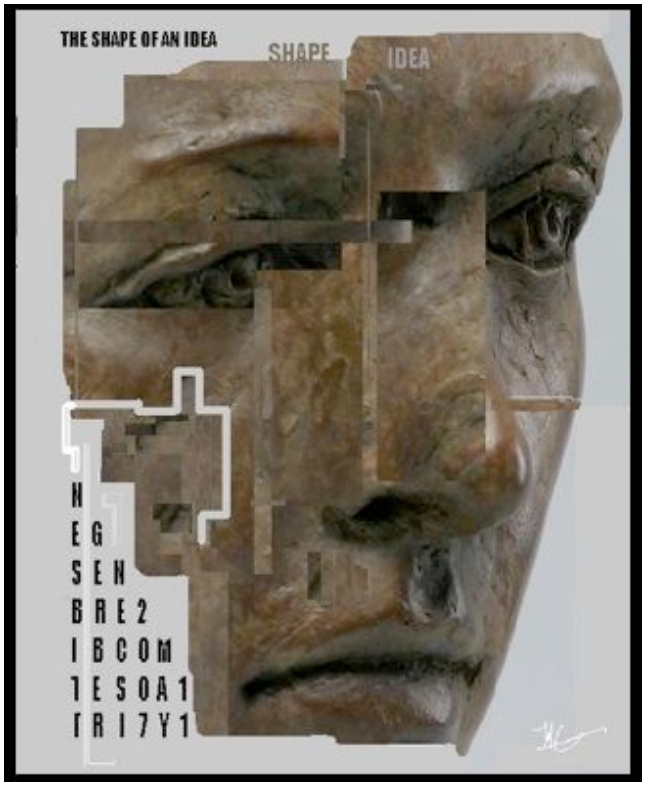
I must point out I am no expert in these things, but it seems the way Einstein and Picasso saw things was not so different. I have read that Einstein's theory of Relativity was inspired from the idea that the Universe had to be consistent regardless of the observer's viewpoint (Stenger, 2006). That is, only a single viewpoint is required to model the universe and it's state will be relative to the observer. This can be used to derive the idea of gauge invariance and the various equations from Einstein's model.

Rather than a single viewpoint, Picasso might represent the world from multiple viewpoints at once. It would be as though the observer was in many positions at one point in time, or that there were multiple observers. The views of this artist and scientist seem almost opposite. I'm not sure Picasso and Einstein ever met, but there conversation about space and time would have been very interesting.



One observer or multiple observers, I'm not sure which view is correct or perhaps they both are. Personally I've become ever more drawn to the notion that two observers, or two viewpoints is just the correct number to use in any model. If these two viewpoints should be opposite in nature then I am even happier, for I have come to find that symmetry is seductive.

The reason for two symmetric, opposite viewpoints is not as logical as I would like, it's just that it better fits a pattern. It is simply a shape that I have found in all my ideas. But to understand the pattern we have to talk more about ideas and ask some hard questions. Where do ideas come from? How are ideas shaped? These are two fundamental questions that artists and scientists often explore.



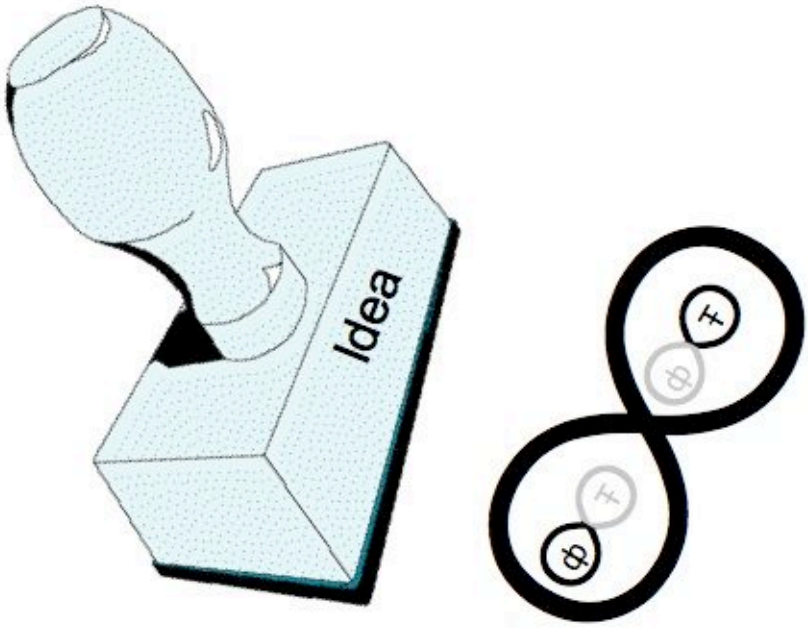
picture by M. Gereber

While in Boston I was painting and thinking a lot about ideas. Well, mostly about one idea. It was an idea I had about ideas. This one idea was, that all ideas, have the same shape. All our ideas come pressed out from this same template. I called the template, "*Simplicity*". Using simple models and rules to evolve complex patterns is one important idea within the field of complex systems. Turing patterns, which have been used to explain the complex formation of many patterns in space and time, are a good example of how simple rules can create complex phenomenon (Turing 1952).

This name, "*Simplicity*" was actually a kind of a joke to me, or a game of opposites, because using this simple pattern you could create all the complex ideas we associate with the world of knowledge. That is, "*Simplicity",* could create all complexity.

Hypothesis

All ideas can be generated from the Simplicity pattern.



Knowing this template might be quite useful, because all ideas could be described in this shape and everything is an idea. It might be useful for creating new ideas. It might be useful for understanding other people's ideas because you would know the pattern being used to create their ideas. It might be useful for creating consilience, or unifying knowledge that has become more specialised and fragmented in recent times.

Unfortunately such a pattern is very abstract and philosophers might argue over whether it is epistemologically adequate for representation. I'm not a philosopher, but I suspect that they might argue about whether the pattern is right or wrong, depending on their viewpoint. But then, they would be using the pattern to argue about itself. I'd rather just like to think of "*Simplicity"* as being metaphysically adequate (). Personally at least as an artist and a scientist I find the pattern both interesting and useful.

There are other problems with universal shapes of course. Communicating them is difficult. Simplicity is also what some people would call a bootstrapping pattern. There are obviously some self-referencing problems having an "idea" about "ideas". No doubt your mind can end up in a strange loop ((Hofstadter 1979), if you are not careful to terminate the pattern at some level. This means you have to stop having ideas about it.

Here is the best painting I can make of *Simplicity*. It was made a long time ago even though I didn't really understand it at the time. Now I know that it is a picture of the room inside my mind where ideas are made. At the time I thought it was a picture of madness, and perhaps it is. Here are some things to notice. The picture is a television, you can think of the signal being received as a "random" number generator. How random this might be is

an interesting question. Perhaps this signal becomes more and more random at lower and lower levels of consciousness. I like to think of artists as being able to tune into lower and lower levels of these subconscious “random” patterns. This random number generator could be as simple as a signal received on haptic senses and acting as a trigger for idea generation. But I’m speculating, like an artist here.

You are viewing the picture from outside-in. However, if you imagine yourself to be inside the room you would be viewing the world from inside-out. This pattern of two, opposite viewpoints, is seen once more in the two windows shown in the room. Perhaps they are looking out on the past and future. Perhaps I am deciding to build a fence or perhaps to pull one down. There are at least two opposite viewpoints shown. I think of the strange object on the table as the subconscious. If you were to go inside this strange object I am sure you would see another room just like this one. That is, the pattern is recursive but and although it might be easy to lose the patterns and confuse levels, it does emerge at all levels.

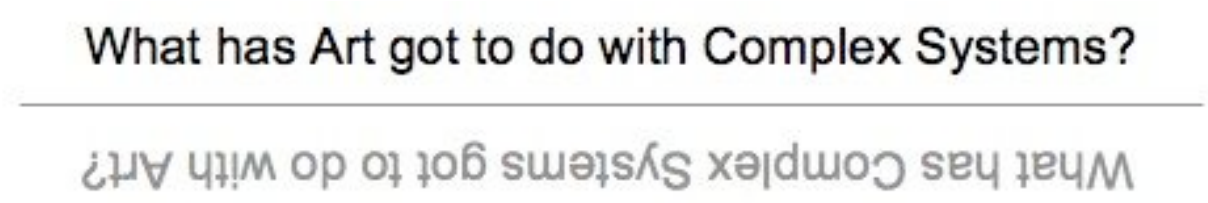
Colour on my Black and White (1981)

We shall leave *Simplicity* here for a moment and return to it later. It really needs some context setting. As a painter I often like to explore context, or frames, or viewpoints. We tend to forget that we often bring an elaborate context to each situation. Many people, for example, are surprised that pictures like the one above are not rectangular in shape. It’s

almost as though there is a rule that paintings must be rectangular. I like to break this rule sometimes just to point out to people that they have such rules. We all often have developed patterns, even quite rigid viewpoints that we are not aware of. That's not necessarily a bad thing as it can be hard to have two opposite viewpoints in you mind at once.

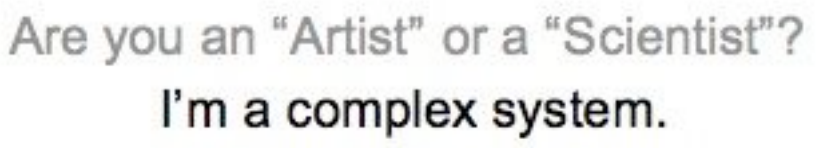
This exhibit explores viewpoints. It explores ideas. It explores the similarity and differences in the viewpoints and ideas of artists, researchers, scientists and engineers. I'm only an artist sometimes and sometimes I'm a computer scientist or software engineer. Sometimes I'm a song-writer. Always I'm always interested in patterns in information. The paintings in this exhibit provide a personalized, conceptual framework for exploring pattern formation in ideas. It touches on many concepts traditionally associated with Complex Systems.

What has Art got to do with Complex Systems? Although this is a question many scientific readers may be curious about, the question that concerns me, as an artist, is, "What has Complex Systems got to do with Art?".



This is because it was actually through my artwork that I discovered the science of Complex Systems. In my painting, I was working with concepts such as, symmetry, continuous versus discrete space, simple models, parts and wholes, grouping and abstraction. Suddenly I discovered that these concepts had much in common with the ideas being explored in the field of Complex Systems.

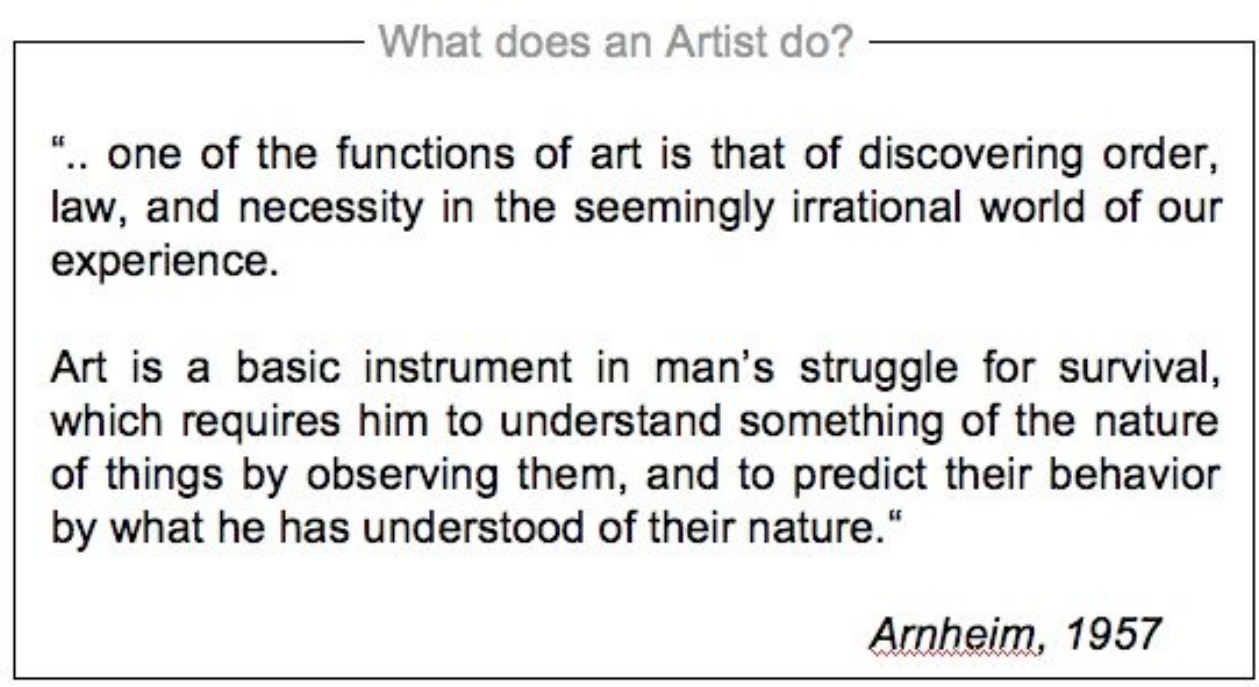
Therefore this paper is a discussion of concepts that seem to concern both the scientist and artist, if you like, the Einsteins and Picassos. The paper is presented for the scientist from an artist's viewpoint. The connections that are drawn may be intuitive and not necessarily stated in a way that is falsifiable.



One question I get asked a lot is; "Am I an Artist or a Scientist?" Well I have been painting and song writing since about 1974 and some people say I'm an artist. Although I have also studied Medicine, Mathematics and Computer Science and so some people think of me as a scientist. So am I an artist of scientist? Of course the slightly clever answer is that, I am a complex system.

Perhaps a better answer is that there is not much difference between what I do as an artist or scientist. My PhD was in Information Visualization and so I make pictures of abstract data. I also work with sound displays and so I also make sounds from abstract data. I deal a lot with issues of perception, visual, auditory and even haptic (touch) perception. I often work in mapping visual information in space, while using sounds to present information requires mapping auditory information in time. Hopefully this should make my science seem a bit more like my painting and song making.

Of course I may be presuming that the scientific readers will already be able to answer the question; "What does an artist do?" Here is a definition for what those who have trouble answering this question:



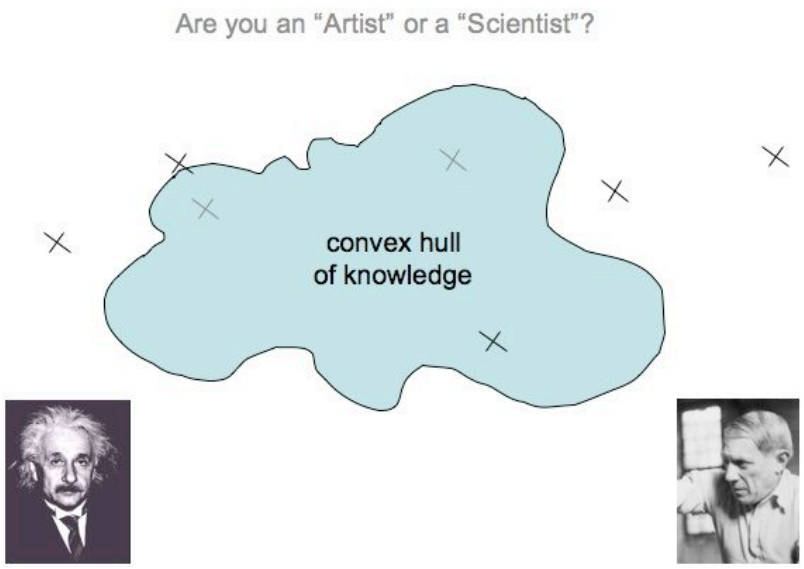
Hopefully this definition from Arnheim sounds familiar to scientists, although they may be surprised to think of artists as having such similar interests to themselves.

As an artist my principle interest is "concepts" or "ideas" and how they are created and shaped. Creativity is important in most domains and two questions I think about a lot when making my art are, "Where do the ideas come from?" and "How are ideas shaped"?

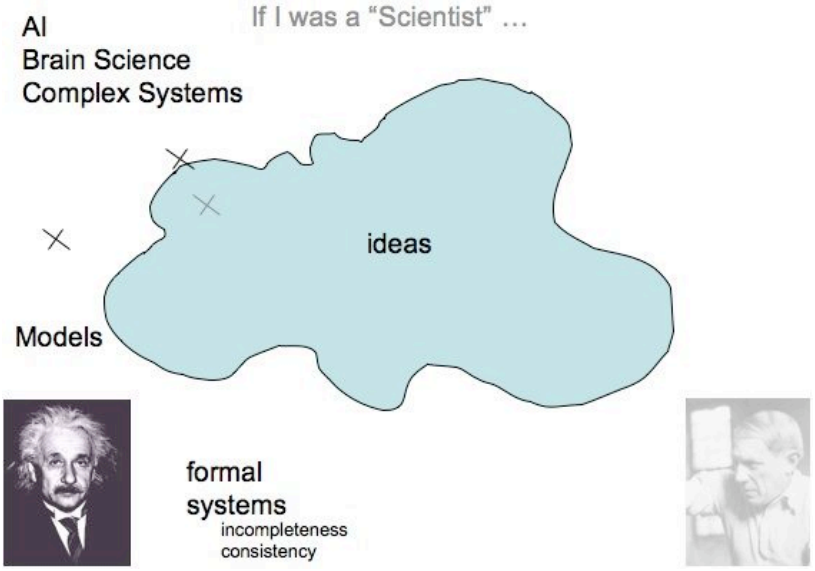
Below I have shown a picture of the "convex hull of knowledge". This is a slightly amusing phrase I once heard a mathematician use to label the collection of known ideas. Scientists and artists are most regarded if they work outside the existing collection of known ideas. Of course, venture too far outside the convex hull of knowledge and your ideas can seem strange or odd. At the very least, very new ideas require much bridging before they can be joined to the collection of known ideas, or this convex hull of knowledge.

The new ideas that Scientists create can be thought of as "models". Science works within formal systems, based on mathematics. It is important that these formal systems provide consistency. It's also important in science that models are stated in a way that can be falsified.

Unfortunately, even very formal systems such as mathematics cannot describe all possible models or theories. Godel's Incompleteness Theorem has had a lot to say about this.



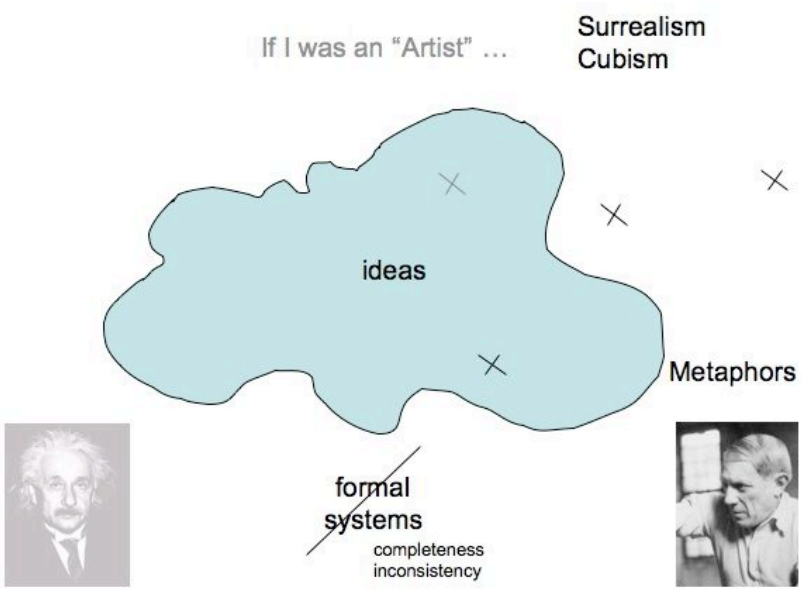
Anyway this has all been described in much better detail in that excellent book, Gödel, Escher, Bach (Hofstadter 1979). Despite incompleteness, science is still very useful for many things and if I were a scientist and interested in the world of ideas, then I would be working with models of creativity. Perhaps I would be working in a scientific field like Artificial Intelligence, Brain Science or even Complex Systems.



As an artist I certainly feel justified in rasing the question about whether the world of all possible ideas can be adequately covered, that is if we can have completeness without including the less formal systems of enquiry, such as art.

Although I do seem to remember reading somewhere that Completeness might be possible in formal systems if we allow for larger sizes of infinity. This all seems to hinge on the size of Cantor's set, as it is Cantor's "diagonal" that is critical for proving that theorems with a Gödel number can be constructed that do not exist within the formal system (Hofstadter 1979). That is, that a formal system will always be incomplete.

As an artist I work, not with models, but with metaphors. (Of course metaphors are very much like models.) It's hard to imagine a less formal system than art, where the context of all ideas is only the artist's own mind. Of course the ideas or metaphors can be inconsistent, but at least it does allow for completeness. However, I think that working with Ideas, that completeness is sometimes as important as consistency. Perhaps what we need for completeness is the two viewpoints of both Art and Science.

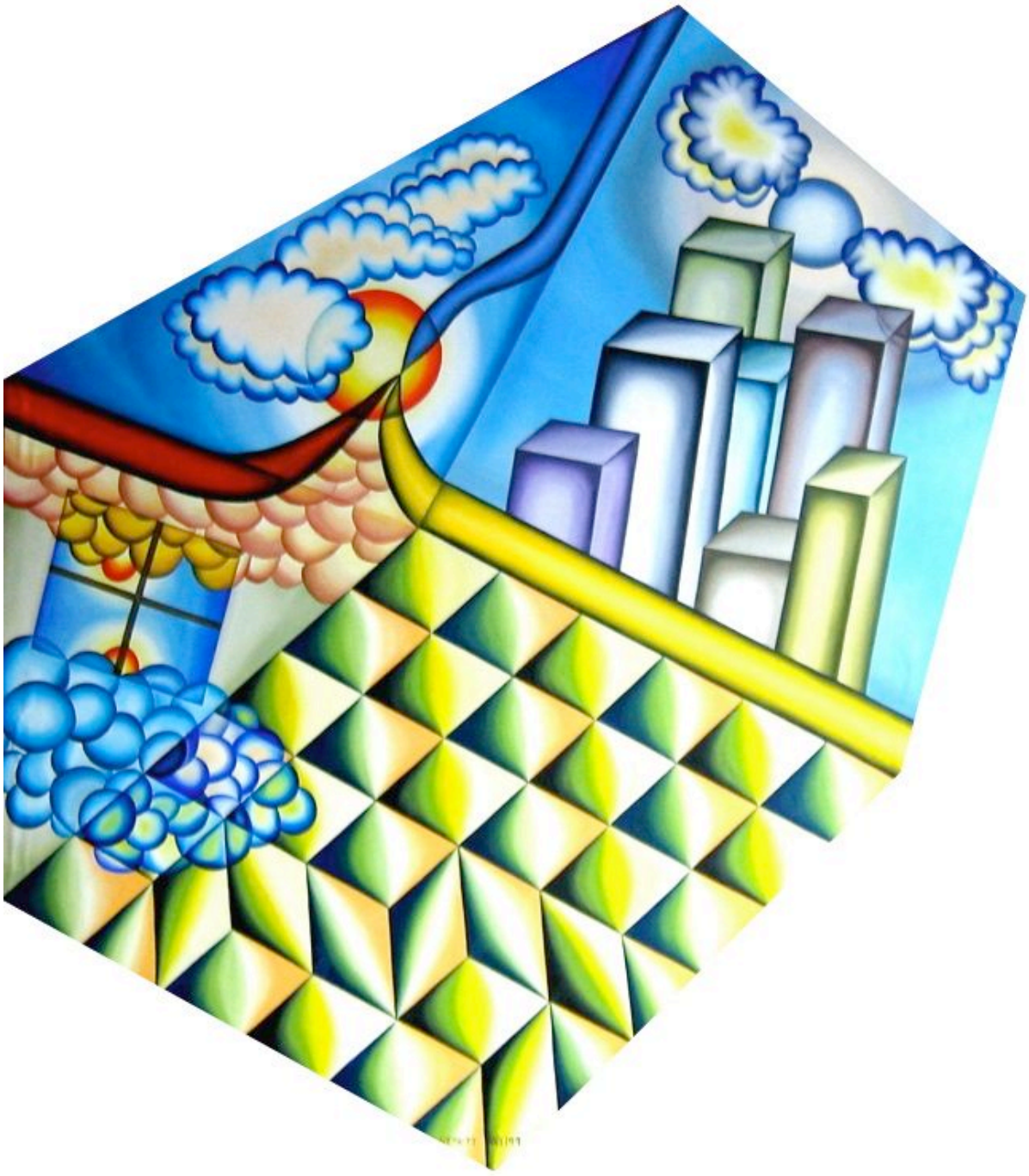


When people look at my metaphor paintings they say they are reminded of Surrealism or Cubism. There are some overlaps and I can see why people see these influences. Of course I am a product of the culture I grew up in and so it is difficult to deny that there may be some influences from these movements.

I am certainly interested in Surrealist ideas, particular the concept of synchronicity. The symbolism of Carl Jung also resonates with me. Because I paint "metaphors", there is this obvious connection with Surrealism, although my pictures emerge during my waking hours rather than in dreams. In the end I have found that all these symbols reduce to a battle between two opposite views, the straight line and the curved line.

Token Tears (1998)

Cubism is perhaps even closer to the way I think about picture making, as I am interested in viewpoints. However, not quite the multiple viewpoints of Cubism. Although in my early work I described my painting as Juxta-Positional Perspective. I was interested in space that was observed from different viewpoints, but positioned together in the same context. Later the number of viewpoints reduced to two. As I have mentioned I now regard two symmetric opposite viewpoints as the correct way to see the shape of things. Two observers with opposite views, both of which cannot be true at the same time. Of course the interesting point is when they are both almost right.

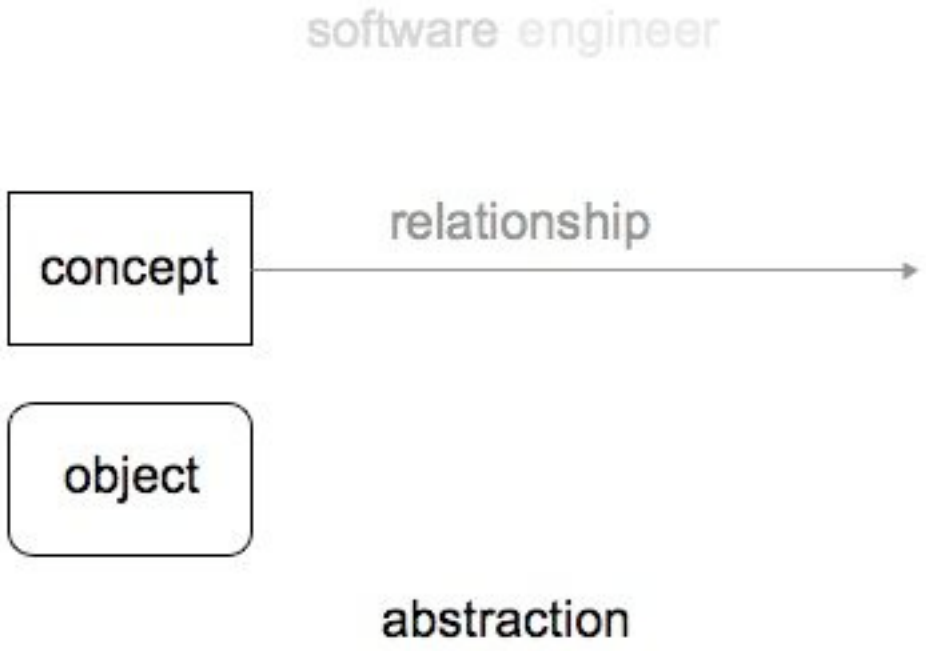


More Than One Way of Looking at Things (1999)

Perceptually we encounter something similar this when we look at the well-known, ambiguous cubes in the picture above. It is only possible to view the cubes in only one of two ways at any one time. The picture itself is on one level separated from it's external world which is delineated by the frame. I am also concerned with the context or frame of the picture. That is why I create odd-shaped pictures. It helps to reinforce the importance of interpreting a picture within a context. The picture itself and the context of the picture form two levels. If you like you can also think of these as two further viewpoints, the picture

itself and the context. This may start to sound somewhat recursive, or self-similar and that's exactly how I've come think of ideas. Always right or wrong, depending on your viewpoint. Of course your viewpoint may also be right or wrong. Such self-similar patterns are well described and self similarity is a property associated with fractals. Perhaps in ideas it would seem that thoughts, at least as they occur consciously are only approximately self-similar. Certainly the cortex is not symmetric, even though lower-level brain structures may be. Indeed non-symmetric brain architectures are relatively rare. It seem that in terms of ideas this complementary pattern of opposites has emerged in many ways over time (Kelso and Engstrøm 2006).

Perhaps this all seems a bit odd, that I should be thinking about the two different viewpoints of Science and Art, and always being in two minds. Actually most of the time I work somewhere in the middle of the two extremes. I spend a lot of time as a software engineer, designing software, user-interfaces and displays of information. This requires some science and art, and some knowledge of where the limits of each domain impact on design decisions. Actually software engineering has quite a lot to do with modelling ideas as well. A particular topic that is familiar to artists, scientists and software engineers is that of "*abstraction".*



Since the late 1980s, software engineers have tended to do a lot of Object-Oriented modelling. Actually they don't think about objects much, but rather more general concepts, called classes. (Objects are unique instantiations of a general class.) They model by describing classes and the relationships between classes (concepts). Relationships between concepts can take two basic forms, aggregations and inheritance. Aggregation is also called the "has-a" relationship. For example "a car has-a engine". Inheritance is also called the "is-a" relationship. For example, "a car is-a vehicle". Together with concepts these two relationships are enough to model many ideas. Actually this is not so surprising as the Object-Oriented modelling approach originally grew out of Artificial Intelligence, and was used to describe knowledge using a semantic network.

The nice thing about abstraction for generating ideas is that more abstract concepts can be reused in lots if ways. For example a “car” has certain key attributes, but there can be lots of small variations on the idea. An abstraction can be instantiated and changed to create unique objects that have the properties of the parent class. This is called specialisation-generalisation and uses the is-a or inheritance relationship.

Another approach to creating new ideas is to join existing parts together in new ways. For example, we might take parts from a car and a boat and make a new type of vehicle. The new vehicle might be an idea that is more than we would expect from the sum of its parts. This is using aggregation to create new ideas. Aggregation is also called the whole-part relationship. That the “whole can be greater than the sum of the parts” is an expression that is usually attributed to Aristotle. It is an interesting idea explored in Complex Systems and also in Gestalt principles.

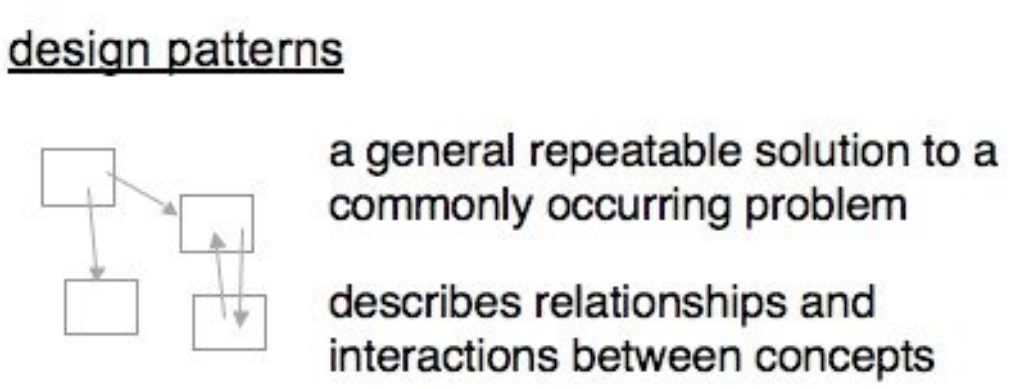
Abstraction has of course a long tradition in painting. Although this was rumoured to end with the work of Malevich who argued that nothing had the most meaning because it had the most interpretations. This actually sounds a little like the “Theory of Nothing”, which I have read in physics, and reasons that the “Theory of Nothing” is the same as the “Theory of Everything” because everything has the same complexity as nothing (Standish 2006).

Fire, Earth, Air & Water (1997)

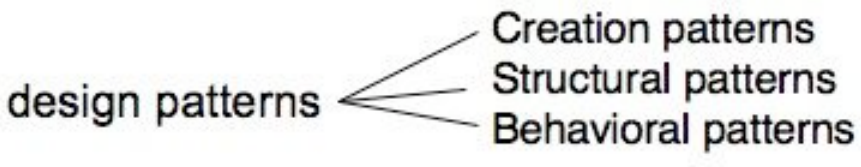
Despite the end of abstraction I still like to use it in painting, both specialisation-generalisation and whole-part relationships. Fire, Earth, Air and Water is a good example of both these principles being used. Here is my abstraction of the forms of fire, earth, air and water, these elements were the fundamental modelling units used by the ancient scientists of Greece. As a scientific model these basic elements seem unsophisticated today. However, they did allow for sophisticated inventions such as coin-operated holy-water dispensers for the temples. In this picture, I have integrated the four parts into a whole, although the separate canvases create a break between the elements. It is obviously a whole, but also parts. Hopefully the whole is greater than the sum of the parts.

"What has been will be again, what has been done will be done again; there is nothing new under the sun" (Ecclesiastes 1:9-14 NIV).

Of course in the world of software ideas, one might also argue that old ideas are repeated. As of 2007 at least most ideas can be reused with little trouble, rarely now is software built up from its very basic parts. This is thanks largely to the successful use of aggregation and inheritance. However, apart from these two principles there is another way to reuse ideas in software design and that is by using "design patterns". Design patterns were first described in Architecture by Alexander in 1977 (Alexander, 1977). These patterns are at a higher level then aggregation and inheritance and describe a repeatable solution to common problems. The solution is one that can be reused and is defined in terms of a group of concepts and the interactions that occur between them.



There are three main types of design patterns of interest to software engineers, creation patterns, structural patterns and behavioural patterns (Gamma et. al 1995). All these patterns are interesting to consider in idea making. Of course creation patterns are perhaps the most interesting.



I'm not going to talk more about design patterns here, but hopefully the connection between software design, idea modelling and creativity are a bit more obvious. Of course

software engineers may sometimes deal with concepts like printers, bank accountants, customers, etc. but they can also work with more abstract ideas or meta-concepts. Design patterns, abstraction, instantiation, inheritance and aggregation are all meta-concepts. Other meta-concepts that need to be considered by software engineers are *processes* and *viewpoints*. Processes describe temporal aspects or the way things change. Viewpoints are important as software systems may need to satisfy the viewpoint of many different stakeholders in a project. The idea of viewpoints or frames and context also belong in the realm of Artificial Intelligence and have been investigated for many years (McCarthy and Hayes, 1969).

design patterns

process

viewpoints (frames, context)

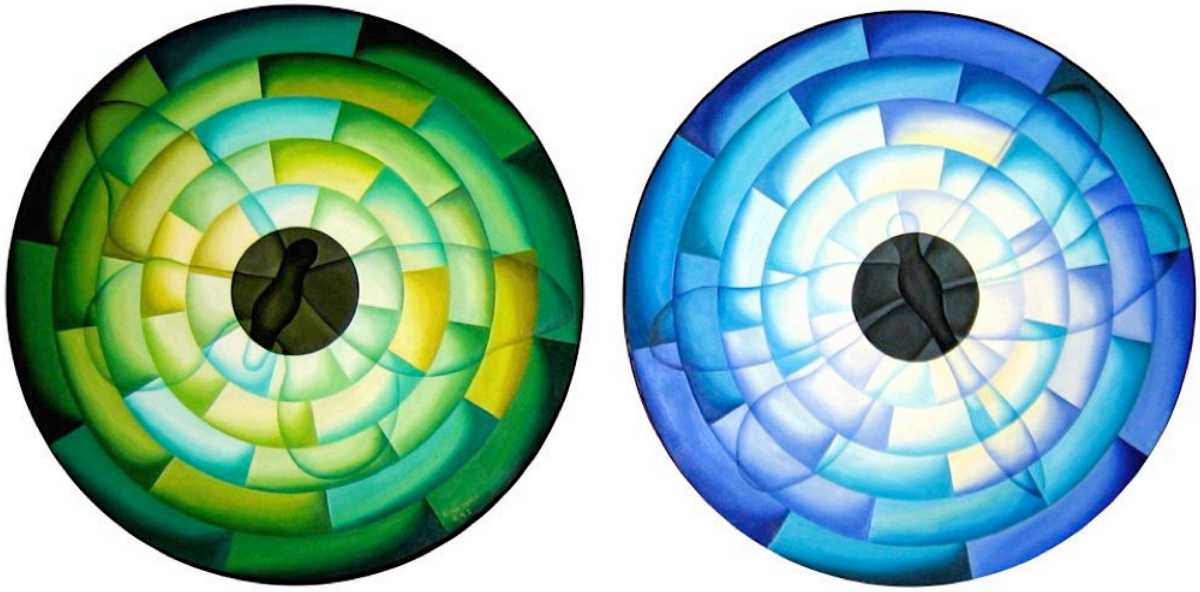
Anyway this discussion began with the question about whether I was a scientist or an artist. Perhaps it is better after all to describe myself as a software engineer. Software engineers are also concept artists. As an engineer I like to find practical solutions to problems.

But we have moved a long way from talking about what Art has to do with Complex Systems. I said that initially it was my art that attracted me to this field because the scientists in that area were working with lots of similar ideas that were emerging in my art. Lots of concepts being used fro modelling in Complex Systems were also cocepts I was working with in my art.

What has Art got to do with Complex Systems?

(simple models, recursion, symmetry, levels, subdivision)

I like simple models and I also like symmetry, recursion and complementary, opposite viewpoints. I like to model things on different levels, or levels within levels. The idea of subdivided versus continuous space is also interesting. Below are two pictures that illustrate some of these concepts.



Green-eyed Butterfly, Blue-eyed Dragonfly (2002)

What I like so much about butterflies and dragonflies is not just that they can represent opposites like female and male, but that their behaviour also seems so opposite. The random flutter of the butterfly gathering pollen and the more strategic flight of the hunting dragonfly. I like to think about the ideas that are created in each of these two creatures. I wonder what they're thinking. *Simplicity* is a pattern of symmetric or complementary opposites. This idea of complementary opposites for modelling has also been explored by neuroscientists and some contend that it is ubiquitous in ideas. (Kelso and Engstron (2006). Here is another picture exploring the same idea, along with a mathematical concept. it is called, Strange Attractors.

Strange Attractors (2006)

Now that we have started talking about ideas used Complex Systems we should also discuss evolutionary processes and the shaping of ideas. This connection between the process of evolution and the way in which ideas are created and evolve was described in Artificial Intelligence a long time ago (Turing 1950). Mutation and natural selection are very appropriate ways to think about how ideas are created. Ideas evolve.

How are ideas shaped?
(evolution, mutation, selection, variation, drift, ordering, serendipity, synchronicity)

As an artist it is often the most random of mutations that occur in the work that are more interesting then the well-worn patterns that occur. Often my works are only slight mutations on existing themes. Sometimes it is hard to escape the conscious designing that occurs as the picture is made, I find my thoughts reusing old ideas. If I want to really explore the mutation aspect I make a dreaming stick. Dreaming sticks were used in old cultures as a meditation and communication aid. The process is fairly simple, I find a stick I like and decorate it with paint and found objects. Even though I may be painting around a theme every imperfection in the wood, each chance find can create mutations that led to something unexpected. Below are some examples.

A Robot's Dream of Free Will (2007)

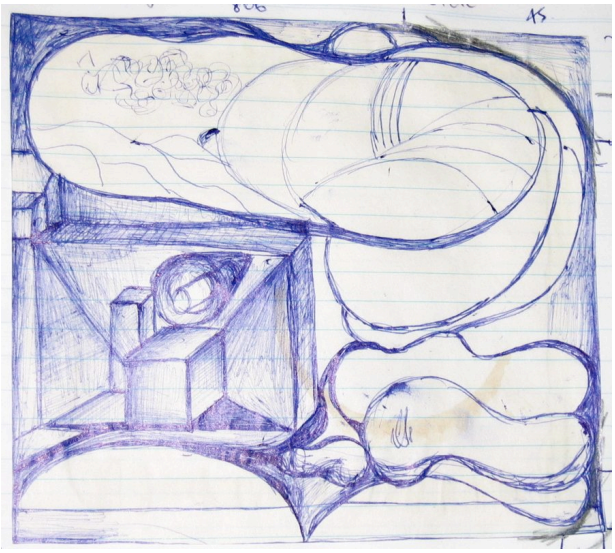
In "Red, Yellow, Blue (chromodynamics)" I painted an idea evolving. You can read it from left to right, in which case one idea is born and becomes two ideas. Or you read it from the right and see two ideas become one idea. At the exhibit a mathematician took a print out of the painting and joined the end to the beginning to make a torus. We were surprised, but delighted, to see that the picture join up quite well and so the end of the space was also the beginning.

Red, Yellow, Blue (chromodynamics)

I'm never completely sure of the space from which my paintings emerge but they seem to be more of a visual impression than anything. They often just have a vague spatial form, a picture of lines in space. Sometimes it's like they emerge at different levels of consciousness sometimes revealing more realistic objects or recognisable symbols. At other times the pictures emerge as compositions of curved and straight lies.

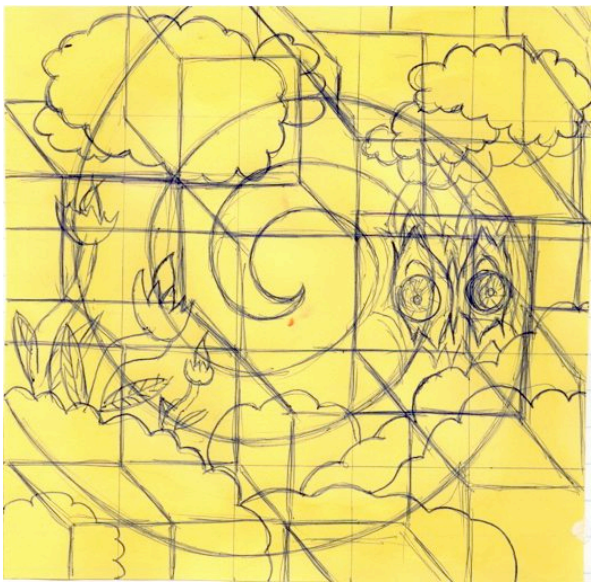
Below is a picture of the original sketch and final painting for "Left Side meets Right Side". It's a picture of an idea emerging in my mind. Of course the strict division of the emotional and logical sides of the brain is not an accurate physical model. Much symmetry has

evolved out of brain structures, especially at higher cortical levels. However, this logical (dragonfly) and emotional (butterfly) model is still interesting to consider.



Left Side meets Right Side (2006)

Painting do not get produced in my head in an ordered and structured way. I'm no regular idea machine. There are periods were lots of ideas are created and other periods where no ideas appear. My idea factory runs not on clockwork but more like the ideas come in waves generated by a storm. If it's appropriate to think about a storm of ideas then physicists would I think agree that it only takes a small perturbation in initial conditions to cause unexpected outcomes in a complex system such as the weather. Below is my homage to 3D cellular automata, as well as Zen and physics. It is called "A Butterfly's Wings".



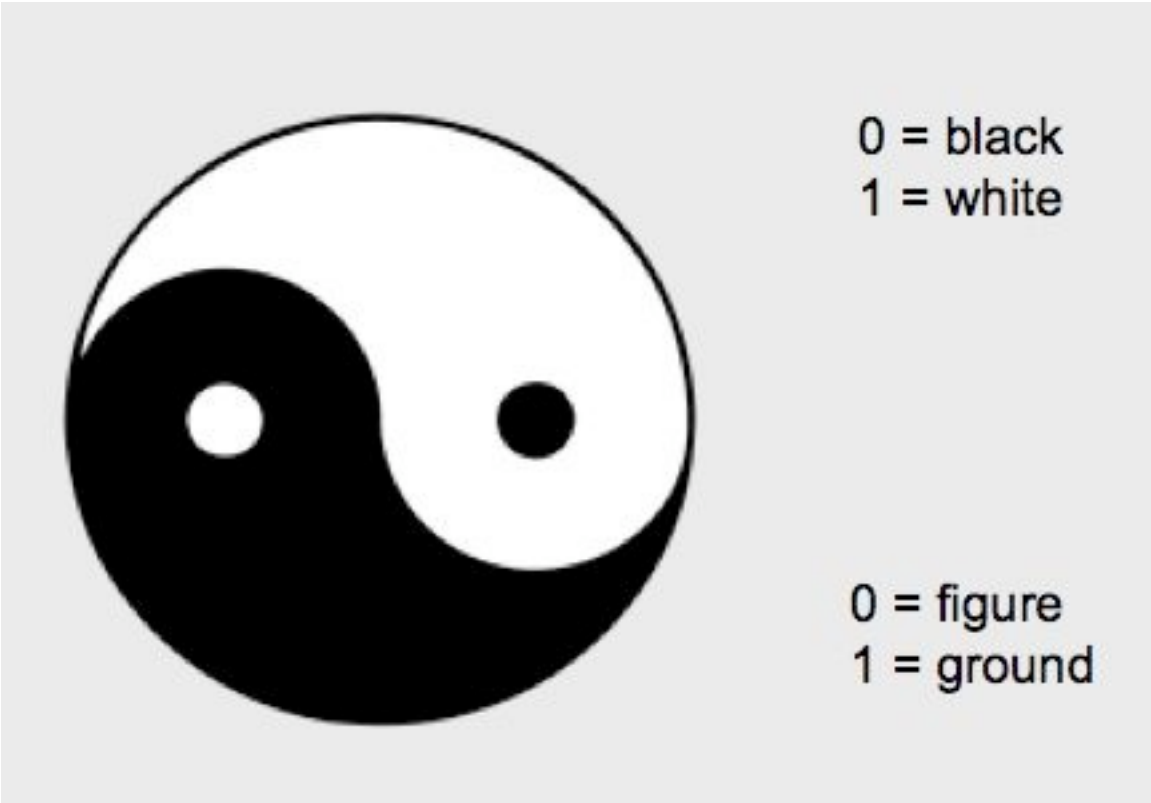
A Butterfly's Wings (2006)

Getting back around to Zen Buddhism is interesting, although I was were going to avoid philosophy. But in the end this is perhaps not surprising as the closest thing to the

Simplicity pattern, is inherent in the eastern philosophy called the Taoism. People have made comparisons between Taoism and Physics before (Capra 1975) although these grand theories that build on simple models, called bootstrapping theories have been criticised in the past. Apparently these ideas are not consistent with current ideas of a standard model based on quantum field theory.

Anyway I'm certainly not a physicist, and the mathematics get too tricky for me, especially those probability distributions of quantum mechanics. I understand that many are still looking for unification theories based on symmetry (although) the meaning of symmetry is somewhat different in mathematical terms. Another interesting direction is to try derive the fundamental principles of physics from Information Theory. Again I'm not sure what all those zeroes and ones and bits of information have to do with physics. But it does for some reason bring to mind the complementary black and white nature of the Taoist symbol.

Although this Taoist symbol is often seen used in modern culture, it is as frequently shown incorrectly (Arnheim 1961). The key is to show the symbol on its side with the black half at the bottom. This creates the correct perceptual ambiguity so that both the white and black half alternate as figure and ground (Arnheim 1961). If we return again to *Simplicity* the connection to this symbol should be clear. We have two opposite viewpoints, only one of which can be true at one time.



This is the end of the discussion on *Simplicity* for now. It was a somewhat vague, view from an artists mind. However, I know the scientist in my head is also taking a good hard look at this pattern in my ideas.

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