Seminar Notes On ‘The Technology of Visualization and Visualizability in the New Economy’.

Abstract: The 'New Economy' is making businesses both more complex and more volatile. Financial statements are supposed to give a realistic picture of what a company is up to, but such auditing as an exercise in representation is often simplistic. We need to ask whether the complexity of some businesses is getting beyond the reach of our present representation technologies and how this might be improved. Arthur Miller explores the use of visual metaphors in science and suggests possibilities for business organizations. Max Boisot explores the I-space and its relevance to complex learning organizations.

(Note: Only the main presenters are identified by name - Ed)

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by Geoffrey J.C. Higgs 18/11/02

Max Boisot

We may be able to look at the problem of visualization and visualizability as one in knowledge management. Admittedly this is a fairly amorphous discipline because it doesn't have very solid contours, though it may be through the kind of analyses Arthur has given us that a more rigorous one could emerge. What I want to do is to introduce something called the 'I - space'.

The I-space is thinking about how knowledge might evolve in a social population and I will try to apply the concepts and ideas that Arthur has given us. Arthur has focused on developments in physics and in particular the quantum theory.

I want to look at ENRON and ask whether we can use some of the concepts to better understand the situation. We may think there was wrongdoing but we may also ask the question, 'how was it possible to behave so opportunistically?'

As an article in the Harvard Business Revue said: the problem an auditor has is that in circumstances such as occurred at ENRON he or she is very vulnerable to cognitive bias. We are dealing with a complex phenomenon. ENRON was asset light and was a multi-layered set of conditional contracts, options and derivatives, which were all interwoven. This made it difficult for an outsider (and sometimes perhaps an insider),to understand what was going on . There was also hype, but the opportunism would never have occurred if there hadn't been a cognitive problem.

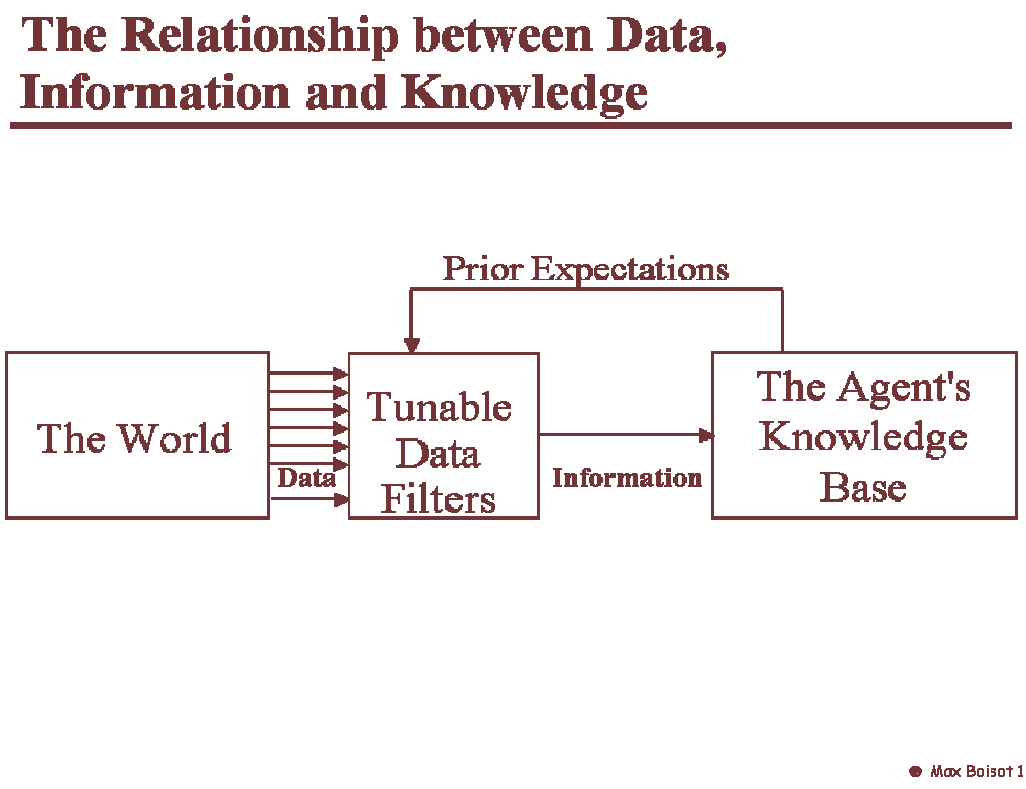
We may be dealing with a crisis in the technologies that we use to represent the situation. The accounting system developed over 800 years from bookkeeping in the 11 or 12 hundreds in Italy was designed to account for slow moving events: a ship went to sea, stayed away two or three years and then came back. The problem is that we still have that kind of accounting system with us. Arthur was talking about that kind of problem in physics on the micro scale, we are talking about the macro.

So ENRON, before it is a problem in ethics or for the governance is above all a problem in knowledge management. In science we have visualization, the move from image to code and we have technologies of presentation for doing that. Then visualizabilty is the move from the code to image using rules of transformation of symbols. In the case of a business we might take transactions as the basic unit of analysis. So we look at physical events like purchasing and selling and record them as an abstract representation of large number and then we manipulate these
codes to a series of rules and we begin to get outcomes that may be difficult to understand and analyse. They may not be as intuitively accessible as we think. We are active in the process of establishing these processes and the way we represent things to ourselves will determine what we see.

Andy Clarke, a worker in artificial intelligence, developed the idea of 'tune-able filters'; our expectations tune the filter that extracts from the data via the sensors to those things we expect to see. This doesn't mean we won't get surprises when the interpretation

doesn't fit, but this leads to a very simple schema about developed data (page 31 illustration 14).

Illustration 14 – Tune-able Filter.



Data impinges on some filtering process which may be the senses or instruments; anything which can register the data and allow you to extract information from it. What you see is a loop, which says prior expectations (and you should add valuations and preferences). In other words what you get are other sources of bias than purely cognitive bias. You end up getting expectations that act upon the filters and thus determine what gets through the filters. It's partly what registers as data with a particular agent and partly the kind of objective information we can extract out of it.

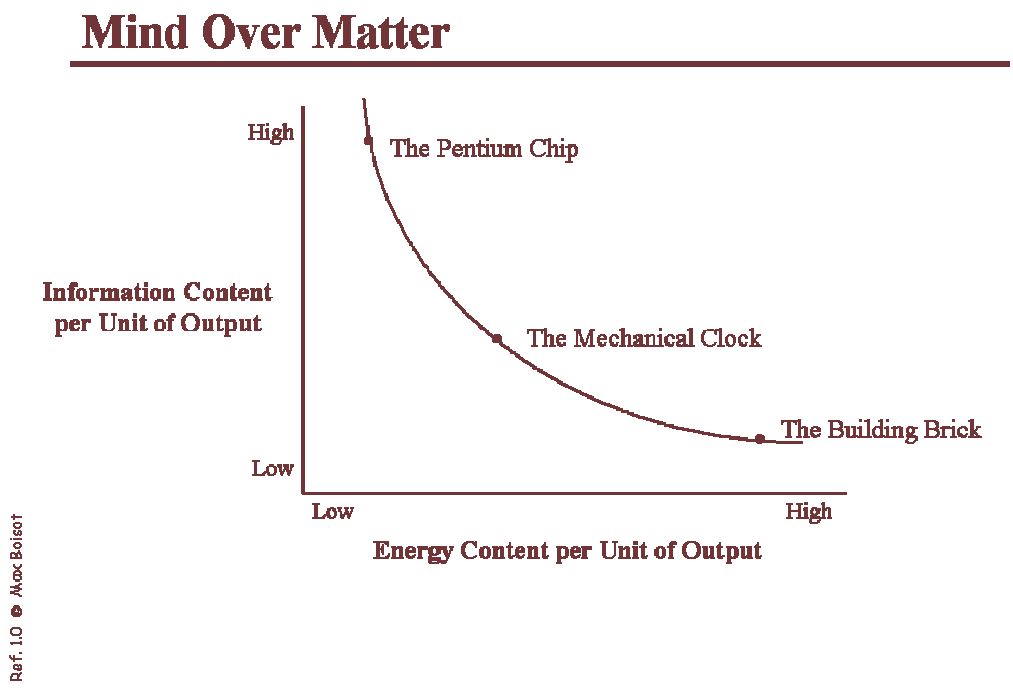
So in this respect the theory we have of firms is also going to reflect the way we look at them. If we look at the history of the term 'firm', what we have tried to do with a collection of often complex events has been to turn them into a thing, an object. So we give it a legal personality. We try to bound it and stabilise it and treat it as a unitary actor who we can take to court. And if we are an economist everything that goes on inside the firm is treated as a black box. There are inputs and outputs and we infer behaviours inside. The history of the 'firm' takes us back to corporations and guilds; to a time when the people involved wanted to be treated corporately and so we end up objectivising it. And this also comes back to what we were saying earlier about treating a firm as an organism; we think of it as having boundaries. But now we are also beginning to think of the company as a complex network which of course doesn't have boundaries. So though

we tend to work through the legal metaphor, with changing communication technology this concept is being loosened up and the change may be causing problems in presentation. We need therefore, a better-matched method of presentation and some of the points raised by Arthur about particles may help us.

Here is one way I'm thinking about the 'firm' and it's not yet formalised. Any system admits to different degrees of coupling between the elements and sometimes we get tight couplings which tends to give a mechanical system. But where we begin to loosen the system up so that there are alternative relations, the importance of information creeps into the system and we're depending on communication to keep the system together. So in a typical firm mechanical action and informational action work together. But because loose coupling allows different combinations we may have a combinatorial explosion and we say 'how can we choose in such a system?'. 'How can we manage such a combinatorial explosion?'. I must cheat a little by asking 'How does an intelligent system cope with that?' And what I suggest is that it moves from the embodied forms of knowledge that you get in a mechanical system to representational forms of knowledge. So we handle the combinatorial explosion and economise on the combinations by being able to represent some of the privileged states ahead of time. These privileged states will have certain *gestalt* qualities and they will act as attractors in the system's states of possible representations. And our conclusion is: 'if you move from the firm as a thing with some rigid coupling to one which is loosely coupled as a network, you may need to start working on new ways of representation which either allows an outsider to understand it or the firm itself'.

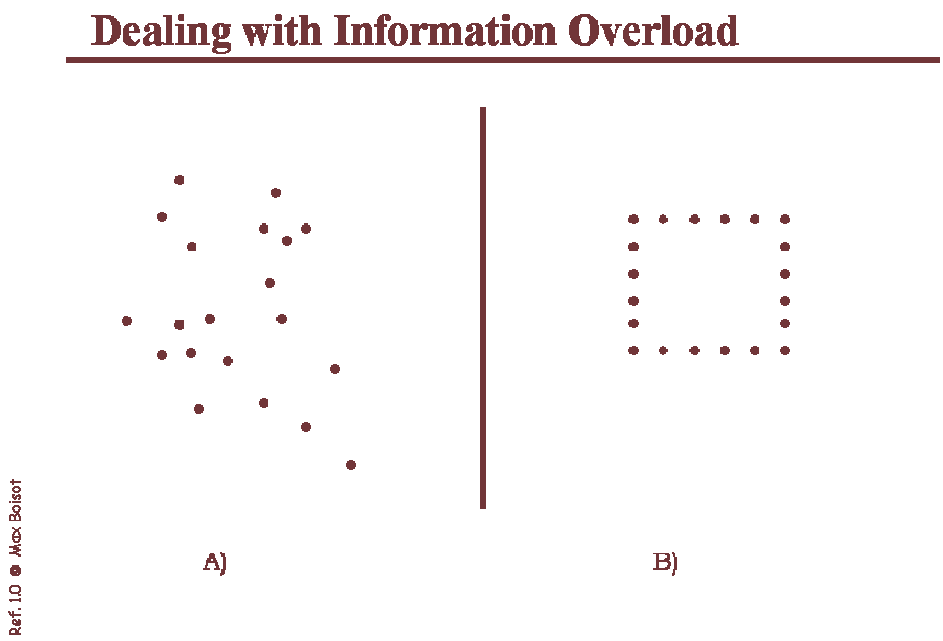
What I want to show you is a kind of production function though not simply the kind of function that has energy or physical resources on one side and information on the other. This function has a directionality which shows how memory in a system allows data to accumulate and replace the energy needed per unit of output (page 31 illustration15).

Illustration 15 – Mind over Matter.



The illustration shows something such as a building brick has an extremely high-energy input and low information content whereas the pentium chip has the reverse. The energy component is replaced with an information component and this can be seen in human systems and perhaps some biological systems. With the scientific revolution of the 17th century the information input has grown rapidly and by the time we get to the pentium chip the information content is very high for a relatively modest consumption of energy. I know this is not a rigorous production function but it is a nice way of thinking about it. However, what happens as we move up towards greater information input is that we meet a very inconvenient phenomenon called information overload and we can illustrate this by the dot diagrams on page 32 (illustration 16.)

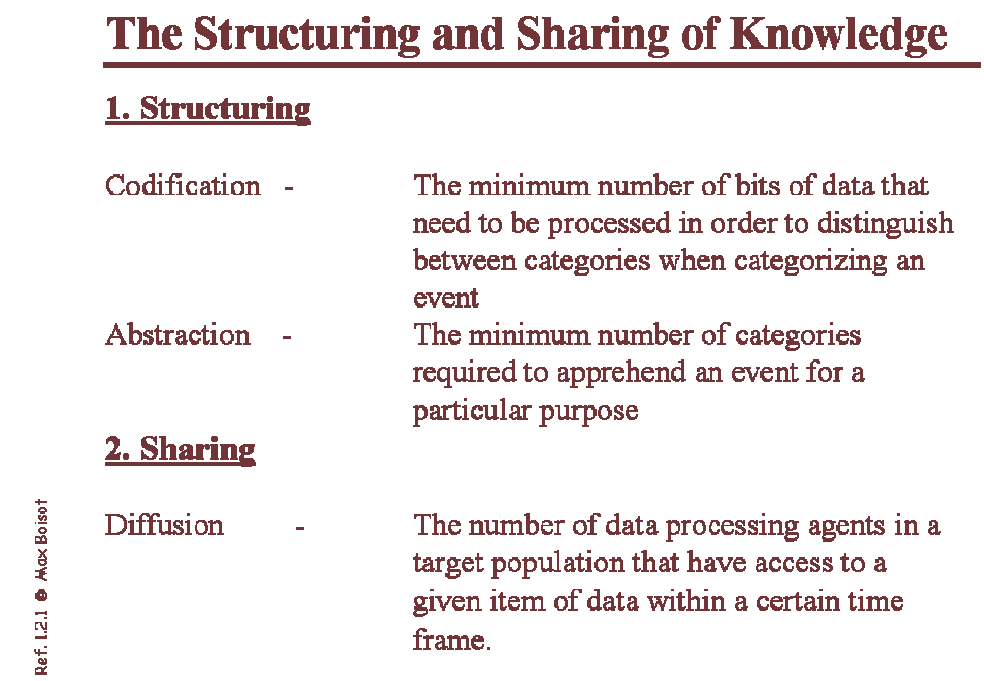
Illustration 16 Dealing with Information Overload.



Here we have two patterns with an identical number of dots, but if we wished to transmit an exact description of each then we would expend much less energy and money by transmitting the one on the right because the one on the left doesn't have any structure. So one way of dealing with information overload is to extract or impose structure on the data of our experience and that's where memory and 'know-how' comes in..

The concept of the I - space involves the principle that the speed and extent to which data flows through a population is a function of how far it has been structured and shared. So we have a cognitive dimension, which is the structuring and a social dimension which is the sharing (page 32 illustration 17).

Illustration 17- Structuring and Sharing of Knowledge.



If coding is the process of assigning phenomena, codification is essentially a process of creating categories to which phenomena can be assigned. Something is well codified when you don't have to spend a lot of time deciding how to assign it to categories which are ambiguous. So straightforward ones might be 'is it blue or pink?'. ' is it heavy or light?'. Where you have well defined categories and the phenomena are well defined it can be done quite quickly and I've taken a kind of complexity measure of codification which goes back to the work of Karlgomerov and Chaitin which says 'how many bits of data do you need to process in order to assign?' (see the illustration below for a more rigorous definition).

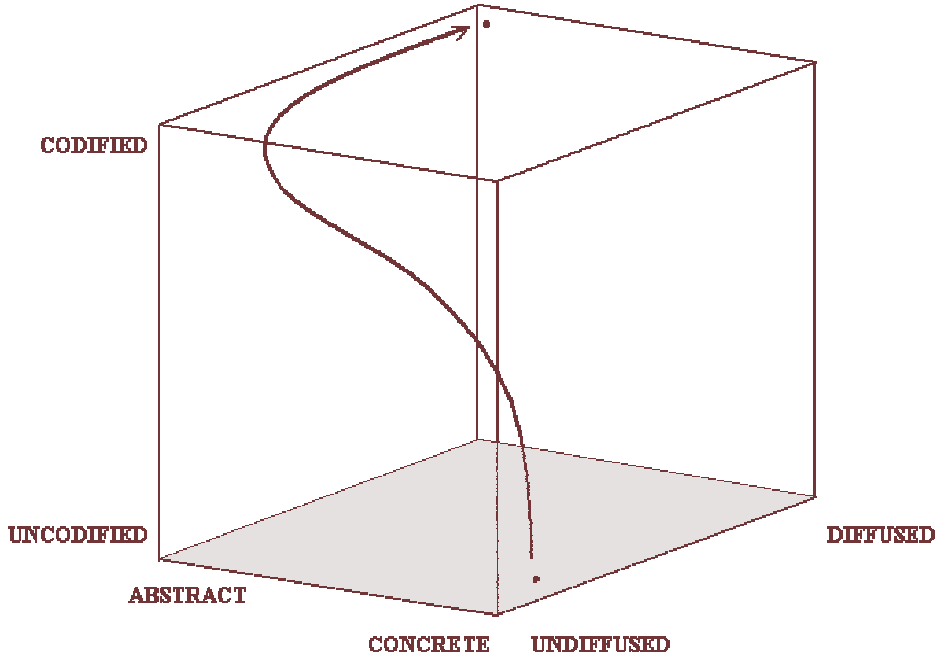
I was intrigued by Arthur's comments on metaphor because I related them to the work of Fred Dretske, a philosopher who says: you can take 'abstraction' as the process of treating things that are different as if they were the same. And I realised that the metaphor is the first step of the process and that you can eventually combine categories. Sometimes in poetry you move across very different categories but very often what you are trying to do is to get one category to stand in place of another and to that extent you need to have some degree of equivalence between the categories. In doing so you reduce the number of categories that you are going to use. If this was an art class we might all extract different things from this room in a particular way. You might get a line drawing, you might get colour but everything else is treated the same. So it is the minimum number of categories required for the apprehension of an event for a particular purpose.

Sharing or diffusion is the number of processing agents in the target population that have access to a given item of data in a certain time frame. An agent may be a human but it can also be a bug or a nerve cell, anything that can process data.

The next step is to draw a cube in I- Space where codification, diffusion and abstraction are the axes (page 33 illustration 18)

Illustration 18 – Codification – Diffusion - Abstraction.

Figure 1: The Codification-Diffusion-Abstraction Curve in the I-Space



Ref. 1.2.1 © Max Boisot

At the bottom information is relatively concrete rather than abstract. It's uncodified rather than codified and doesn't diffuse very rapidly over time. This is the world inhabited by Zen Bhuddists where communication is ambiguous, or fuzzy and you can't codify and you need to communicate in face to face situations in order to overcome the ambiguities that lack of codification gives rise to. As you move up codification and abstraction work in tandem. You can clarify the difference between categories and begin to abstract by having some categories merging or substituting for each other. And as that happens so you increase the speed of your diffusion so that when you get to the top of the cube you are dealing with information that diffuses quite rapidly and is highly compressed into codes. The thing to note with relevance to what Arthur has been saying is that down at

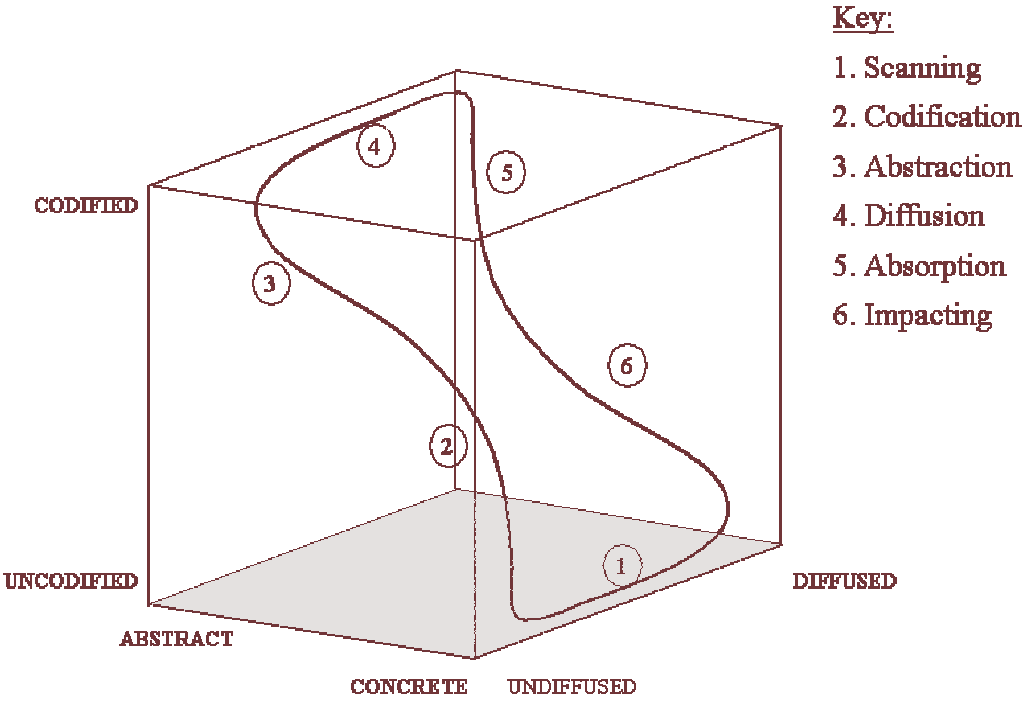
the bottom you are in a world of highly contextualised data, in situate or embedded. As you move up it becomes thin and fluid but loses content and that's the price you pay in going from an image to code. If you are the one that is performing the process you retain the image and the code, but anybody receiving the code may not be aware of the process that has been gone through to generate the code. This loss of context obviously increases the cognitive load of the recipient unless the code can capture the full complexity of the context from which it is derived.

There is also a learning cycle set up. When you receive a code and put it to use in some further context you build up a tacit penumbra of knowledge as to how to use the code. You may not be able to say what it means in a semantic sense but you can say 'I'm getting a feel for what this code is about'. It's the difference between a freshman physicist using a formula and a professor who's been using it in the field or the laboratory and has built up an intuitive understanding of what the code means. So if we ask what the process is by which we generate visualizability from the code we can say there is scanning and codification, then an internalisation as you move back from the codifying towards the abstract which basically says that as that process develops you become more able to use the code in the real world. Coming back to a world of concrete application further facilitates the development of those intuitions.

The following diagrams show the steps of a social learning curve with some analysis of the process within a community is shown on page 33 (illustration 19)

Illustration 19 – Six Steps of an SLC.

Figure 2: The Six Steps of an SLC



Ref. 1.2.2.1 © Max Boisot

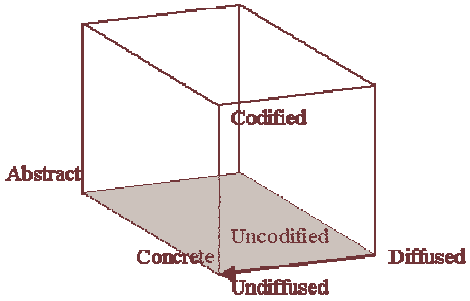
The completion of the cycle in diagrammatic form looks a bit odd because it looks like we go from a situation where data is diffused to a situation where it looks undiffused but this actually demonstrates the limitations of this particular representation.
There's decontextualization as you move from the front of the cube to the back and there is further decontextualization as you move outside the situation in which the code (replicates?). So we're now beginning to see a big and significant difference embedded knowledge which is highly local and dis-embedded knowledge which can be very distant in content from the point where the knowledge originated.

Scanning (page 34 illustration 20) is what we do to the original data but it is interest relative for the individual or for a section of the community. If this was a painting class and we were all paint Eve we would not all paint her the same. Your individual knowledge is something that connects you to the world through purposes. And one of those purposes is that it enables you to respond to threats and opportunities in the environment. The threats and opportunities and the data you're scanning can sometimes be very fuzzy, lot of ambiguities, hard to discern, easy to misallocate or mis-categorise. So detection can be very slow and this depends on the kind of patterns that you are looking for. What I mean is that we might all share the data but we don't necessarily share the patterns that we generate from it. We may not have the same schema that we either impose on or extract from the data. If we're not looking for a pattern we may never see one though it might it may be right under our nose. The data may be public but the patterns may be unique. And a lot of creativity comes in at his point. When Alexander Fleming was looking in the Petri dish he saw something anybody in that laboratory could have seen before, but he was the only one to see a meaningful pattern. So tune-able filters determine the patterns we extract from the data but there may be distortion as people adjust the schema for their own use.

This is an important point relevant to the ENRON case in that this process of pattern making can be very easily distorted by group pressure and if you end up seeing a pattern nobody else sees it may not be a very comfortable place to be and you keep quiet. There have been plenty of experiments in social psychology where people conform and actually have their perceptions shaped by the exhortations of the group and we would expect this kind of situation to generate the kind of biases that were being referred to in the Harvard Business Revue. Even in science there will constraints on the language you can use reflecting a bias in that particular scientific community.

Illustration 20 – Scanning

Characteristics of the Social Learning Cycle: Scanning



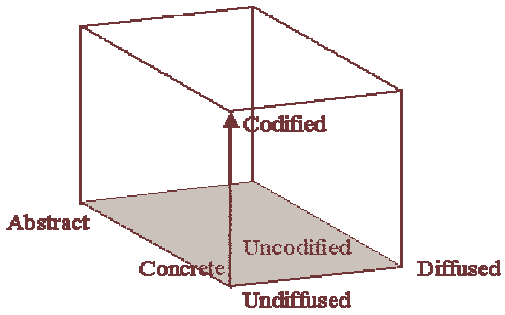
- Identifies threats and opportunities
- Signals are often fuzzy.detection is slow and uncertain
- Data is often public, interpretations are not- they are often unique
- Group pressure can distort the scanning process

Ref. 1.2.2.1 © Max Boisot

Codification is your response to what is scanned (page 34 illustration 21). You have a pattern but it may be rather fuzzy and you have to go through a process of getting structure and coherence and eliminating uncertainty and ambiguity. In this way all acts of codification are acts of selection so what is rejected is a source of bias in itself which can generate conflict. There may be stakeholders in the particular alternatives that were not selected. So we can think of codification on an individual cognitive process going on inside our head or we can think of it as a social process involving all sorts of conflicts.

Illustration 21 – Codification

Characteristics of the Social Learning Cycle: Codification



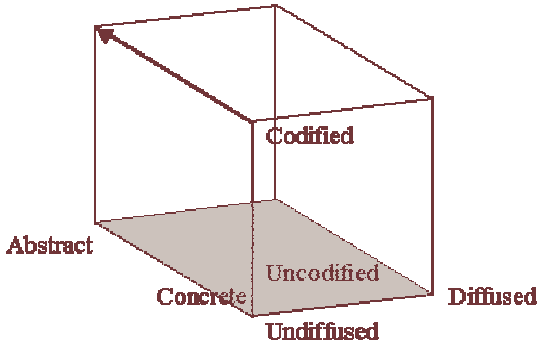
- A response to what is scanned
- Codification gives structure and coherence to the response
- It reduces uncertainty and ambiguity
- It sheds uncodified data along the way
- It generates conflict by forcing selection

Ref. 1.2.2.1 © Max Boisot

Abstraction when the created knowledge is applied in many more situations than the kind in which you have created the code (page 35 illustration 22). This is a way of economizing on data processing and we can think of codification as a form of economizing on your copies of processes. There is an economic principle at work here which relates to the point Arthur made earlier; that what you're interested in is getting to the underlying structure and shedding what you think is extraneous. Both codification and abstraction have a highly hypothetical structure and you have to test out whether your codes are compatible with a given reality.

Illustration 22 – Abstraction

Characteristics of the Social Learning Cycle: Abstraction



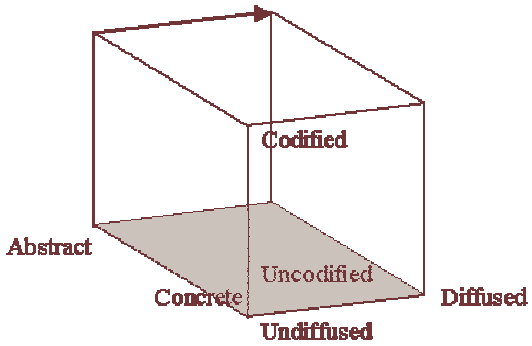
- A move from the specific and concrete to the general and abstract
- It reduces the number of concepts and categories that one has to deal with
- It saves on data processing by agents
- Abstraction seeks out the structure that underlies appearances
- Abstraction has a hypothetical character
- Abstraction is a conflict-laden process

Ref. 1.2.2.1 © Max Boisot

Once you've codified and abstracted, diffusion can happen quite quickly (page 35 illustration 23). This means that the material is available in an accessible form even though people don't necessarily buy into it. And it can diffuse quite quickly unless there are steps made to control it. I mean one thing that might block its adoption is encryption. That's a way of making sure things don't diffuse. It's using a code very few people have access to and information that is too easily accessible loses its scarcity value, and we might ask to what extent is controlling the diffusion creating opportunities for exploitation?

Illustration 23 - Diffusion

Characteristics of the Social Learning Cycle: Diffusion



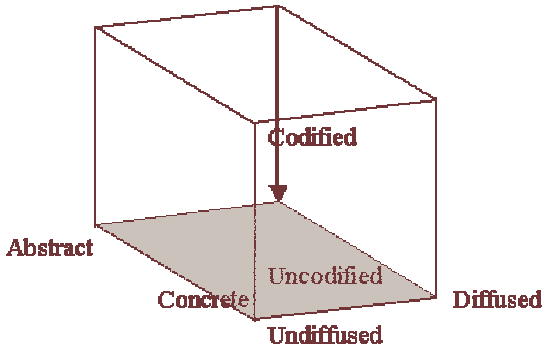
- Codified data diffuses rapidly - unless controlled
- It will only register with those who know the codes
- The data is de-contextualized when it is codified and abstract
- Diffusing data reduces its scarcity value

Ref. 1.2.2.1 © Max Boisot

Absorption is receiving the codes and applying them in some kind of a 'learning by doing' pattern (page 36 illustration 24). As we work the codes we build up a stock of practical experience. Visualizability seems to do with the working of those codes, somehow building up our intuitions. The process may lead us into conflict with other underlying mental models because the code may have a structured implication that does not fit either with our common intuitions or with the paradigm in which we are working. Diffused tacit knowledge is the realm where a lot of our implicit models of the world are located; the things we take for granted, our common-sense views of the world and the paradigms within which we operate. And the reason I want to point this out is that in the process of working from the codes and ultimately having to integrate with the repertoire of implicit models often the connection doesn't get made and you end up trying to resolve the anomalies. I suspect that one of the great paradoxes of Einstein was that though he was one of the people who contributed to the codes of the quantum theory he had great problems reconciling them with the implicit models. If the code doesn't reconcile with other mental models we can either reject it or try to reconcile it and start another round of the cycle.

Illustration – 24 – Absorption

Characteristics of the Social Learning Cycle: Absorption



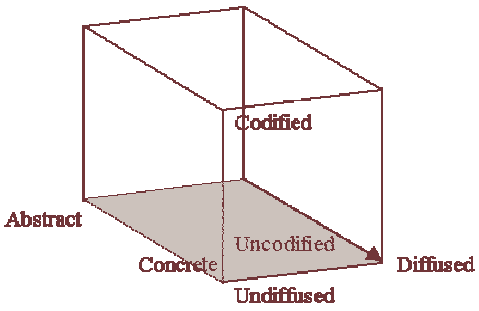
- Newly diffused data is applied in a learning by doing "fashion"
- An uncodified stock of practical experience builds up around the codified data
- The codified data may or may not match the "common sense" world of the user
- If it does not, a new round of scanning and learning is initiated

Ref. 1.2.2.1 © Max Boisot

Impacting means having gone to abstraction we take whatever we've got up there (abstracted and generalised) and bring it back into the world to apply it in other concrete situations (page 36 illustration 25). This recontextualises the knowledge but it may do so in a very different set of circumstances to those in which the model was first extracted. This is the process in which the codes are tested. Moving back is hypothesis generation moving forward is hypothesis testing. Medieval theology was all about moving towards the back whilst Baconian science said, 'we can move towards the back providing we come back towards the front'. There has to be an empirical reference and the reason for the numerous disputes in theology (such as the number of angels that could dance on a pinhead? - Ed), was that there was no mechanism for doing this.

Illustration 25 – Impacting

Characteristics of the Social Learning Cycle: Impacting



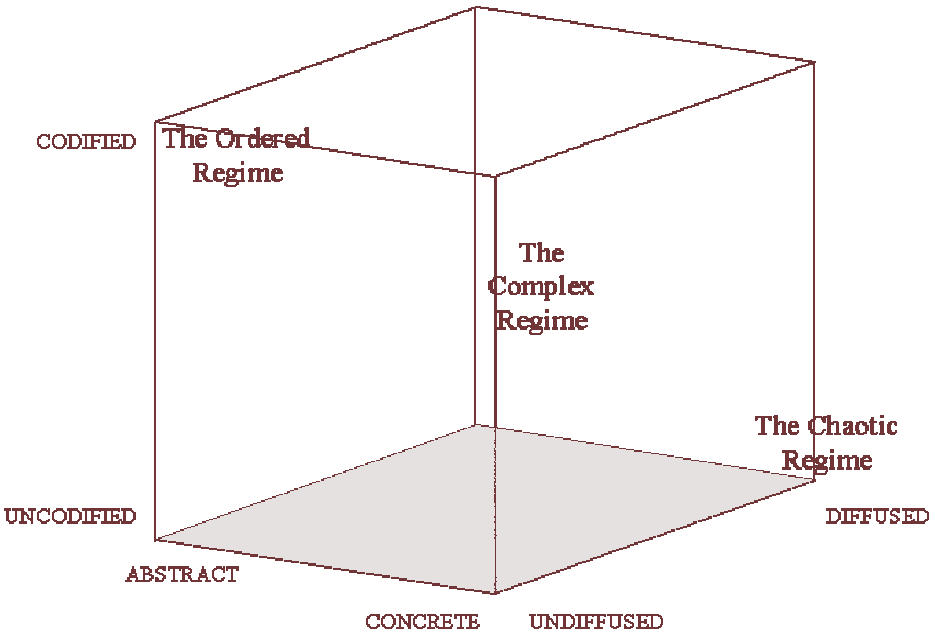
- A move from the general and abstract to the specific and concrete
- Impacting contextualizes knowledge
- It increases the number of concepts and categories one has to deal with
- Impacting tests abstract hypotheses
- Impacting resolves the conflicts generated by abstraction

Ref. 1.2.2.1 © Max Boisot

Companies whose internal links are loose and whose operation depends on information flow are complex. In a separate work I looked at complexity and I suggested that three different regimes of order can be distinguished in the I - space cube (page 37 illustration 26).

Illustration 26 – Three Regimes in I- Space.

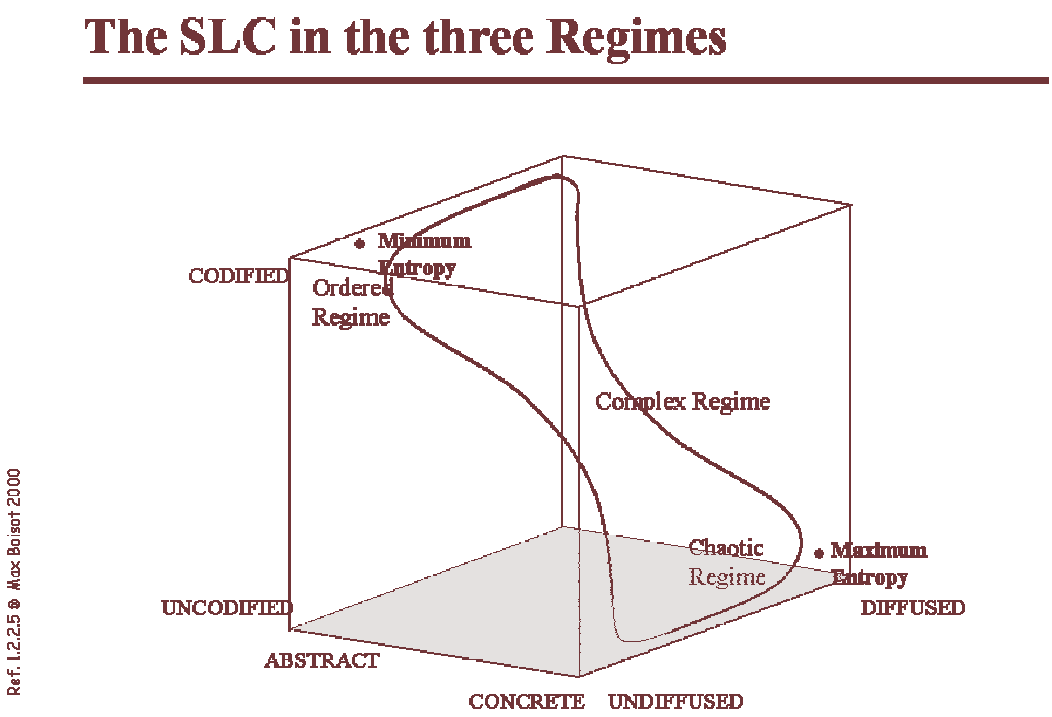
Three Regimes in the I-Space



A system in the ordered regime can be highly codified and its models predictive and mechanistic. In the chaotic regime it is highly diffuse, un-codified and concrete in context. This is an area where there is very little control over the cognitive process because of rapid and changing information flow and it is very difficult to structure. As you move from this regime towards the ordered regime you get increasing structure and decreasing entropy and this links with the work of Stuart Kauffman.

Again there is a cyclical learning process and one of the things we learn is that we cannot stay in just one regime (page 37 illustration 27). We move towards greater structure in order to minimise entropy, but ultimately as we re-engage with the world we have to come back down and tolerate a certain degree of disorder.

Illustration 27– SLC of Three Regimes



I'm also intrigued by the feeling of discomfort new theories generate. This is an area in which we often feel the situation is chaotic and cognitively de-stabilising. We confront our mental models and sometimes completely destroy them. Sometimes the change is very radical and the whole paradigm has to go, but it is also a very creative situation in which ideas rapidly evolve. This may be interesting for analysing the progress of certain far eastern economies where innovation and learning can be very intense within a particular paradigm and produce rapid incremental innovation, but not the kind of radical innovation which arises from a more conflicting melée of ideas.

OK, lets talk about ENRON. It traded in intangible assets and one thing that strikes me is how difficult it is to come up with any credible representation of intangible

assets. What we try to do is to convert existing accounting measures to capture this elusive kind of knowledge. So we start with that problem. ENRON was a very complex network of contracts, conditional contracts, options, derivatives etc. etc. The other problem was that 'Arthur Anderson' actually got to close to ENRON. In other words the very act of getting the embodied knowledge gave it the biases which prevented it from coming up with a disembodied representation.

I've summarized the ENRON case on page 38 (illustration 28). As we all know, the essence of auditing is to create a true and fair view. But we have to ask ourselves in this case 'what is a true and fair view of such an organisation ?' There's a presumption of objectivity which means that: the reasonable man in English law will come up with the same view of this firm if in possession of the same information. We have this idea of objectivisation of the firm but as someone was saying to me earlier: depending on where you stand, you may get a very different perspective and in ENRON we have an interesting case of just that. We have this deeply embedded knowledge generating systematic biases which were driven, not necessarily by cognitive considerations, but by interests. And this made it almost impossible for Andersons to come up with a true and fair view.

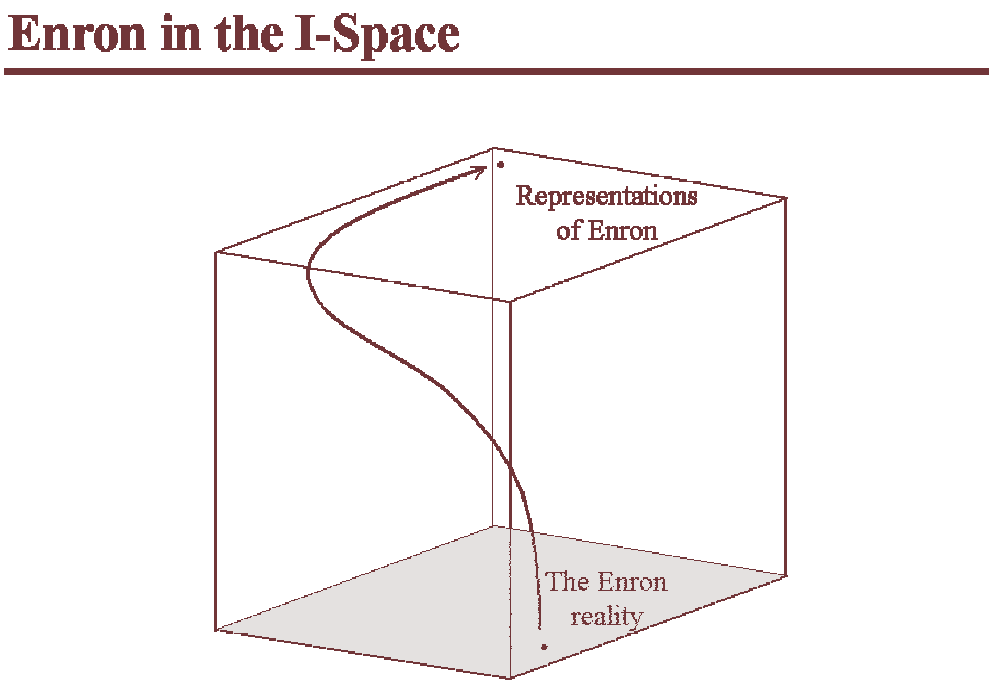
Illustration 28 – ENRON Case.

Applying the Framework to the Enron Case

- Enron was a complex phenomenon that was low on tangible assets and high on intangible assets.
- A large part of its assets were complex networks of contracts – derivatives, options, etc.
- Through its consulting activities, Anderson got too close to Enron – it obtained much embodied knowledge
- This made it easier for Anderson to learn about Enron
- This also made it much more difficult for Andersen to come up with objective and disembodied representations of the complex processes that Enron was engaged in.

Ref. 2.1 © Max Boisot

Illustration 29 – ENRON in I – Space

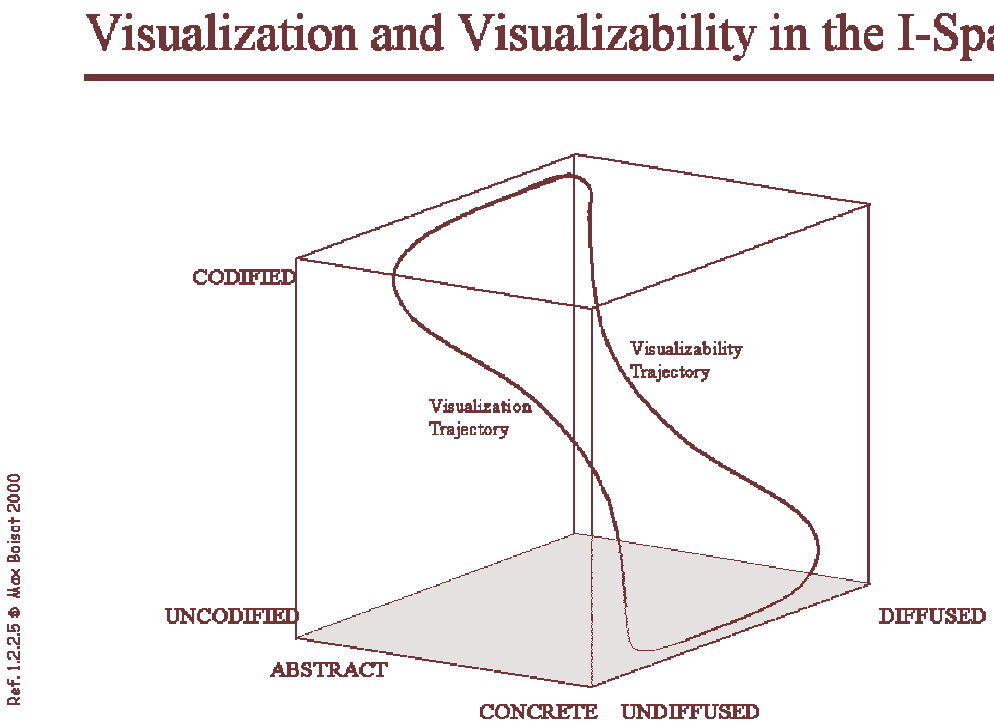


Illustrations 28 and 29 show the task of the auditors. A true and fair view would comprise a series of hypotheses about what was going on about a very complex reality down at the bottom and the auditing process has to manage this trajectory in such a way that it is freed of biases. There has to be an understandable correlation between what is going on down here in this opaque and complex phenomenon and what ends up in the accounting report. And this is not quite the same as what Arthur was talking about, but in moving from embedded forms of representation towards codes, we go through a number of manipulations, computations and combinations. There's a syntax which results in new sentences being formed in the language. So whatever the reality of the situation, and it's possible that few, if any, people understood the whole picture, by the time the data has been squashed into some form of codification, outsiders and probably insiders become totally disconnected from it. I'm not saying that this is how it plays out in Arthur's book however.

And finally there is cycle set up between the visualization trajectory and that of visualizability (page 39 illustration 30) that occurs both in the world of physics and in attempts to understand complex organizations. The trajectory of visualizations becomes increasingly abstract as codification proceeds. The language of codification has to

continually confront new data and visualizability decreases until further visualizations start a new upward movement.

Illustration 30 Visualization and Visualizability



The conclusions of this presentation are summarized on page 39 (illustration 31), though I would like to add some further observations. Even if we only half accept the learning cycle, the concepts of visualization and vizualizability scale up beyond the world of physics and may have something quite valuable to offer in the area of management. As we can see from ENRON the stakes are high in terms of economic process. If we cannot satisfactorily represent people will stop investing or the level of investment will drop to consist of only those people who believe that they can play with the given representations. This is something that looks very different from the traditional market order,which is built on the assumption that the sharing of price information is unproblematic and will move us towards equilibrium. The model of the knowledge-based firm is raising questions as to how feasible this assumption is. If the dominant assumption was that information is instantaneously available as unproblematic knowledge of price and quantity this is now breaking down. The technologies we have for representation have to represent something much more complex than what we have been used to and I'm not sure that the ENRON case has been squeezed enough for the lessons it has to offer.

Illustration 31 – Conclusions.

Conclusion

- Firms are taken to be key institutions in the production and distribution of wealth.
- Today such wealth is associated with information and knowledge – assets that are volatile, fast-moving, and hard to capture using traditional technologies of representation, such as accounting
- We need to take seriously the cognitive difference between visualization and visualizability

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Comment, Arthur
Just to make a comment on uniqueness and ambiguity. Ambiguity is often a catalyst to discovery and the creation of new metaphors. You mentioned moving from image, one part of your I- space to a code on a one to one basis - image to single code. That kind of uniqueness is not often the case and that's not only in psychology but in quantum science as well. In psychology there are two different ways of discussing visual images. Everyone agrees they can be generated from code but its what happens after they're generated that's disputed; whether they drop back into code or whether there's a logic of visual images. And we have a certain amount of indetermination coming in there. In quantum theory, the Bohr theory which began with the A*nschauung* (visualisation) became transformed into a visualizability problem after the solar system model didn't work. The thing came out of that was the Heisenberg quantum mechanics and shortly after the wave mechanics. What happened then was that the two theories were shown to be equivalent so in a mathematical sense there was only one theory that emerged but there were two representations of that theory. We can talk about code that emerges and how intuition becomes transformed by the new implications of that code. For example, the intuition of Aristotelean science becomes replaced by the intuition of Newtonian and Galilean science becomes replaced by the intuition of Relativity and quantum theory. All these are 'moved up' or generated by the underlying mathematics.

Max:

Let me clarify one point. When I said that 'moving up' was a process of hypothesis generation and hypothesis testing, the process doesn't come across in the diagrams because it's not a uni-linear process and is highly evolutionary. Many codes are candidates and the majority disappear . What the diagram does is merely track the general direction and I would expect sometimes this move in science can take centuries. The other thing is that that new mathematics can result in new codes. I mean take the zero. The introduction of that generated and drove a new logic of what could be visualized. So it's a very complex process, which I've obviously massively over simplified.

Comment:
I think the analogy of the painter is interesting as an example of ambiguity and at the beginning of the 20th century the theme in art was ambiguity and this was matched by ambiguity in science. There were the paintings by Picasso and Matisse for example. What you see on the canvass is something entirely different from the model. This brings up an important point about pattern detection in that pattern detection is sometimes considered to be scientific creativity.

Max:
Yes and you can imagine the scanning process as a competitive one, people are looking for fit between the patterns they generate and phenomena they are trying to apply them to and there's a selection process going on as well.

Question:
Why do you say there's a loss of context in code transmittance?

Max:
Lets take an economic example. When I price this glass I'm taking all the myriad attributes that determine its value and compress them into a single figure called the price. What you can't do is to reconstitute the attributes from the price. It's an irreversible move for someone that only receives that information.

Comment and question:
While I think there's a fruitful area of discussion about the economies of large companies here, but I don't think it centres around accounting, but around finance theory. It was the finance theory that was behind what happened at ENRON. The ENRON guys were top MBA's with all the latest finance theory and that's what led to this 'new economy' notion of contracting in and creating sophisticated financial instruments. It was built around the leading edge mathematical economists of the time. That brought a new syntax, a bit like the move from say cubism in art to other forms of representation. It was a way of capturing both the movement of activities through time and managing them. The question in terms of the I - space argument is, 'looking at ENRON from the perspective of other actors, where would they be located in I- space?' I mean there was the case of the vice president who sent the memo to the chief executive saying, 'we need to look at this' and

the reply was 'how would I know I'm not an accountant I cannot understand that form of representation'. We could also look at it from the point of view of the Fortune writers and the Fortune chief executives who voted ENRON 'the world's most admired company' for five years running. And look at the way Enron is represented by a leading strategy guy like Gary Hamil: 'In leading the revolution ENRON is the way to do business in the New Economy'. How might they be positioned in I- space?

Max
Well I think if we look at this region here, this is where bounded rationality is getting a bit tired. People at the top have to look as if they know what they're doing and so you get pronouncements that sound a lot more confident than the people actually are. I think there's a social dynamic about pattern making. You end up with a consensus as an attractor, which may not actually be what people think. So there's a social dynamic working as well and it becomes very difficult for a journalist to question the conventional wisdom. The people that say that ENRON's great don't have to prove that it's great, it's the people who say it's going to have a problem that can be sued. So we have a social and cognitive bias in a system which says 'when you're dealing with a complex phenomenon there's always a regression to simple views about it. It's like war. You can't say in the middle of a fight: 'we don't know what were doing'. There's a cognitive perspective that says: 'it is quite ambiguous and messy and foggy', but that's not what you say and what you do say is going to be determined by institutional forces as much as by what you actually see. The whole point of the Harvard Business Review article is that it shows that it's very easy for biases to creep in and then the whole trajectory will be biased.

Let me add something to your point about financial theory. You can imagine a situation in which the man in the street is not going to look at financial theory. What he wants is accounting representations and so there will be two languages and two sets of codes; the financial codes played with by insiders and the accounting codes played with by outsiders. And there will be a narrow circle in which only a few players take part, but who will be able to behave opportunistically.

Comment:
It seems we have a particular problem with complex systems theory. In looking across the market, for the sake of inter-firm comparability, we have to decide on a particular code and if you take into account something like Ashby's 'law of requisite variety' and try to fit intangible assets in you have a problem. As far as visualizability is concerned you are trying to define, (a) on the basis of a variety poor code and (b), one that's been cut down again to allow for comparability across across the market. And because the information is in a standard language which is relatively closed and internally consistent then Goedel's incompleteness theorem applies. We can never have a catch-all language and therefore the knowledge that you are diffusing is necessarily incomplete. This has implications for the learning cycle. Altruistically the learning cycle in a cognitive sense should be driving the scanning, but if we are talking about a 'let's screw everybody else' attitude then operating in an area of incompleteness allows opportunistic behaviour.

Max:
The law of requisite variety is very pertinent to the learning cycle but you could ask 'what is requisite?' If you're in a highly turbulent environment and you try to match the turbulence point by point, you disintegrate. Clearly you are trying to steer between a situation in which you have no variety (bureaucratic), and you fossilize and one in which you're totally sensitive to every whiff of variety and you disintegrate. You need to find a cognitive route that says 'if I can get better representations in my environment, then I only have to respond to the variety that is pertinent to these representations'. To the extent that you have biases going on, you could end up with too much fossilization, or because you're too codified and abstract you suffer loss of sensitivity to context. But you could also say,' I've codified along the wrong axis and I'm looking for the wrong thing'. It seems to me there's nothing in this model which tries to match an ontology and an epistemology which says 'this is true therefore this is the right answer'. The learning process is a constant rediscovery of what you have left out. You can never expect to capture everything in code and you have to move through the cycle intelligently not trying to capture everything. Often the problem you face, and I saw it in BP is that there is enormous pressure to over-codify because people associate that with the reduction of uncertainty, whereas all it really does is reduce the representation of uncertainty.

Question:
I work for an organisation that was much affected by the crash of the Barings bank and I wondered whether you would like to draw any parallels between that and ENRON perhaps in terms of values because I have a slight confusion about what companies are for. For me the deficiency in the diagrams is that they are about a company in a box and not related to the wider society of which it is a part. This becomes particularly important when we're considering the relationship between producer and consumer in the field of knowledge products. And I don't know how you depict it but there are already creators of cultural form who are experimenting (with this kind of social engineering?) who tell us how to engage as an actor and how to communicate in a dynamic way across North / South cultures and so on. Maybe that's a much bigger issue than ENRON however.

Max:
Well take a merchant bank. Merchant banks have tended to operate like clubs and the codes have been implicit rather than written. This is control by socialisation and there's a lot of 'old boy' network in which people ask, 'is he one of us?' The reason for this has been that such organizations are typically entrepreneurial and they live in fast moving environments. It means you have to respond quickly to a particular situation and cannot afford to go through the kind of processes that codes impose. In a way the problems that Barings faced with Nicky Leason go right back to the 'big bang' in 1986. You can think of these cultures as high information environments and so the conditions of information exchange between people will be not by how much ambiguity there is or how much external control, but by how much trust there is between the people. What happened in 1986 was that there was a new market culture in which there were impersonal transactions based on price and code, available to everyone instantaneously and transparently and with the added assumption that the rules and the codes catch everything

that's relevant. A few institutions continued to operate in the old way and did well but the surrounding culture wasn't like that and you got people coming into the firm who were purely opportunistic. And whereas in the past these people tended to be kicked out for not playing the game you had a huge mismatch between the people that continued to play it and those up here with access to instant information. This is of course a very personal view.

Arthur:
Just to pick up on your comment on these observations that we are talking about a company in a box. Some these approximations are the best one can do. The other question we might ask is 'do pictures go beyond code?' which may sometimes be the case or 'is mathematics just a formal representation of pictures?'

Comment 1a:
You made a comment about the same cognitive process applying to artistic objects and scientific objects and theory and perhaps new ways of presenting the same phenomena. For example Aristotelian science being superceded by Newtonian and Galilean theory and that in turn being superceded by Relativity and quantum theory. In business codification is necessary for extending the market for shares and I think you've exposed a real danger in that once you start over-codifying you start losing the kind of context out of which ENRON's problems arose. Once you've created the code in effect you've created objects and it's around those objects that you start getting new meaning precipitated and therefore new sets of relationships and that can provide a new market, in shares for ENRON for example, but if you want to provide a new representation of a knowledge intensive business you may always run the same risk of over-codifying.

Max:
Well yes, though I wouldn't be looking at a single codification, but multiple refractive views. What I will simply say is that those views would shatter many of the assumptions we make about 'the firm'. For example we've always assumed that the boundaries of 'the organization' and the boundaries of 'the firm' are the same thing, but if you look at the legal concept of 'the firm' it is merely a construct of claims on the distribution so we can say that there's a distribution side of the concept but there's a production side today, which consists of outsourcing and strategic alliancing. What we can see is that 'the firm' has burst its banks. So we actually have two different kinds of organizations that are compressed into a single representation called 'the firm'. And I'm saying we may be much better off if we have 'production organization' as one entity and 'firm' as another entity and realise, once we do that, that the complexities of productive organizations are very kaleidoscopic, that there are interactions today with emergent properties of value creation and you can't locate those values created. And how do you appropriate it? What's the mechanism of governance that says 'this particular emergent structure belongs to this part of the network'. And I don't have an answer to that

Comment 2a:

Yes, the firms which provide the biggest challenge would be companies like 'Dream Works', the ones that produce films like 'Harry Potter'. Film companies use fantastically complicated networks.

Comment:
Just a quick comment to amplify that because I think its important in the context of ENRON in that you have a sort of meta - language in the way the firm is represented. And though in my understanding, US accounting may not actually require that you provide a 'true and fair view' in the way that the British process does, that language is logically consistent within its own terms. The term which is missing is really that one outside the box which is one of values and you get into a situation which I have seen in other places: that people begin to believe their own P.R. and lose touch with something rooted elsewhere because the language itself has become so interesting and fascinating. It seems to me that a 'true and fair view' was precisely what was missing in the case of ENRON and allowed people to play the game in narrower terms than those in which would have put some impartial value on it.

Max:
It's a very interesting point that you point out, but the American accounting rules require you to operate much higher up in the I - Space than the British accounting rules which actually require you to apply principles as opposed to rule driven transformations of numbers. Though I'm not sure we can solve the problem of opportunistic behaviour because the key issue that we're facing here is a chicken and egg problem. If you've got an ethical system you can handle more bounded rationality (rule driven?) than if you don't, but if you've got bounded rationality it's going to give rise to more opportunistic behaviour. So the two interact in a very specific way.

Comment 1b
It's about reduction in connection with the kind of firms you mention. The trajectory of the (learning) cycle is skewed or affected because at the top end you have representation selection factors which are not organizational selection factors and you have external forces so that some codifications are privileged above others not in terms of consistency or learning cycles, giving rise to selectivity within the process but of the trajectory itself.

Max:
Yes it's shaped by the distribution of power in the system. One of the key questions is 'who gets to do the codification?' What is it that institutionalises the code? It's a huge power issue. Clearly the larger the population that participates the more your codification occurs here, the more likely it is to bed down here. On the other hand if you successfully codify here and you are here, you have huge power in your ability to understand what you've done before others do.

Comment 2b
What I'm saying is that power becomes more externally held.

Max:
Yes because the minute you have codes you can trade.

Comment3a
I am thinking on much the same lines here. I think it's worth our while to think a bit more about the role of language. If I go back to your basic conceptual framework. The basic proposition was: the speed and extent to which data flows through a population is a function of how far it has been structured and shared. And to be a little bit provocative I suggest that the only shared structure is the language being used in that company. A company or firm is basically a collection of human individuals and their cognitive process are processes involving scanning and detection and interpretation and codification is a language based process. There's nothing 'hard wired' there, but at some stage I think you need an outside authority. And the same happens in science and particularly physics, the codification needs to be published.

Max:
It needs an institution.

Comment3b:
It needs an institution and in that sense the world of firms is very poor. The only codified language in firms is the accounting language. And it's very very limited and made by outside rules, accountant rules. They give the words and the definitions and you use them. So I really wonder when it comes to presenting a firms reality to the outside world the only means is language which is extremely poor and specialised so shouldn't we start thinking about creating a codified language with which we can represent a larger part of that complex reality that is business and isn't a lot of the problem really that we have no codified instrument to represent that reality to the outside world and that poor language which we are presently using is based on the 19th century firm that was largely capital assets in banks and nowadays it has intangible assets which are growing. The reason for that is that the role of capital assets has reduced and the role of people has increased and our accounting language is totally silent on that point.

Comment:
I can think of three examples of why language is important. We talked about insiders and outsiders. Insiders who are at the bottom concrete undiffused part of the cube and finance professionals sit there and their job is to understand how changes in the organisation will impact on the external representation so they follow the trajectory through to see what actually happens to the representations. Outsiders such as analysts and in America, lawyers look at what's happening as far as the legal and cultural aspects of the organization and then follow the trajectories back to what is happening inside the organization. The point about the language used inside is that, and I' ll give you three examples. In the consulting world at our agency the type of things we do are called 'jobs'. At another one they will be called 'assignments' and at yet another they are called

'studies'. People do exactly the same thing but the language that describes what they do is different. My consultancy was bought by IBM and we have two different groups of people in the same organization with different languages or jargon.

Question:
Ultimately language is the first line of codification or the precursor isn't it?

Comment:
Somehow what you are saying about language doesn't sit very well with the idea of network because then you bring people from different jobs and the conflict is that they may have different codes, but perhaps that's how language of codification evolves.

Max:
We think of networks but I would use a thermodynamic model and a high entropy is precisely the reason why the frictional costs of communication are much higher than they would be inside a single organization.