Cybernetics And Human Knowing, Vol.5, no.3, 1998, pp. 56–62

A (Cybernetic) Musing: Variety and Creativity[1]

Ranulph Glanville[2]

In a previous issue, I promised to return to variety and what it offers us, especially vis-à-vis creativity. I will do that here.[3] What I want to show is that, whereas Ashby's Law of Requisite Variety is usually interpreted as placing a difficult condition on us, there is another way of looking at this law that treats it as (amongst other things) the source of creativity. Just how difficult it is to satisfy the Law is the first thing I show in exploring transcomputability limits and how we have traditionally overcome these (thus satisfying the Law). I then introduce this idea that we do not have to satisfy the Law, and indicate how it works in offering increased variety and, hence, a (potential) improvement in creativity, citing our interaction with the World Wide Web as an example.

Transcomputability (Limits to Variety)

Let us start with the limits to variety: that is, the limits to the number of possible states of a system (variety used in the sense of s-variety I identified in my earlier piece, that is, the number of states possible within a system).

It might be possible to argue about whether there is any finite or, at least, calculable number of such states. In part, this is because what the states are of has not yet been determined. However, states are of some system or mechanism. For the purposes of this discussion, I shall use a method based on that first used by Hans J. Bremermann in order to calculate the computational power of matter in the physical universe (one of my favourite conceits), in order to determine limits.

In an extraordinary paper ("Optimisation Through Evolution and Re-Combination"), in the proceedings of an equally extraordinary conference organised by Heinz von Foerster and his friends in the US Navy "On Self Organising Systems and Their Environments", Bremermann proposed to calculate what are, in effect, the limits to variety, by treating matter as if it were a perfect and ideal atomic computer.

---

[1] **Less than the Requisite Variety, or the Wonder of the Unmanageable in Art, Teaching and the WWW.**

[2] CyberEthics Research, 52 Lawrence Road, Southsea, Hants PO5 1NY, UK, email ranulph@glanville.co.uk

[3] The essence of this argument was presented with reference to transcomputability and the internet at the Global Village Conference, Vienna, February 1997 (the argument is that the internet being transcomputable makes it more, not less human). A paper should be appearing in the proceedings of that conference.

The account I give here follows Ross Ashby because Ashby's interest so closely matches both mine and that of Mike Robinson (see below), although Stafford Beer was equally enthusiastic about the use of this calculation.

The computation of Bremermann that Ashby cites shows the following.

A gram of matter computing at the speed of light can compute a maximum 10^{47} bits per gram per second. (The assumption is that atoms are used as markers or locations (computationally, addresses) for the bits of information.) This number is named Bremermann's Constant, in tribute.

This number is wonderful, fantastic. But it mustn't be taken literally: it is ballpark only. However, as Samuel Beckett has his hero Molloy report, after computing his rate of farting,

> Damn it, I hardly fart at all, I should never have mentioned it.
> Extraordinary how mathematics helps you to know yourself.

Ashby extends the argument. If the earth had been a computer for the (estimated) whole of geological time it would have been able to compute a maximum of 10^{73} bits.

We are going to use these figures only to get an order of magnitude sense, so the exact numbers don't matter. In fact, as Ashby demonstrates, even very large numbers indeed may, at this scale, be ignored. So, for instance, whether we should use atoms, or some sub-atomic particles, does not have any significant effect. At these magnitudes, numbers are inconceivably supra-astronomical. On this basis, Ashby determines that it is reasonable to claim that:

> Everything material stops at 10^{100}.

It is easy for us to make systems that exceed this number in their number of potential states. For instance, an array of 20 by 20 lamps can have 2^{400} states, which is 10^{120}, give or take a little. So there are not enough atoms in the universe to mark each of these potential states. This condition, where the numbers required exceed those of the atoms in the (physical) universe, is referred to as transcomputability.[4] There is nowhere for the variety of the system to be marked. And thus Ashby's Law of Requisite Variety cannot in practice be satisfied.

We should also note that, with numbers of this size, what we think of as very large numbers are often completely insignificant. As Ashby indicates, if you subtract 10^7 from 10^{10}, you get a number that is, to all effects and purposes, still 10^{10}. So

10^7 is 10,000,000

10^{10} is 10,000,000,000

$10^{10} - 10^7$ is 9,990,000,000

---

[4] For an interesting investigation of transcomputability, see Rauterberg's discussion "Activity and Perception: an Action Theoretical Approach" (1997)

and 9,990,000,000 is hardly distinguishable from 10,000,000,000 (the difference is 0.1%).

(For a fuller account consult either Bremermann's original paper, or Ashby's reworking in his "Introductory Remarks at a Panel Discussion".)

The Classroom

It is clear that we have no problem in establishing systems that have a transcomputable number of states.

In a wonderful paper "Classroom Control: Some Cybernetic Comments on the Possible and the Impossible", Mike Robinson uses transcomputability to help us understand what happens in the classroom.

In a nutshell, Robinson's argument goes like this.

We might reasonably argue that each brain has a finite, if very large number of potential states (because it is made up of neurons, and we choose to believe in physical determinism). We might further argue that the difference in the number of potential states does not vary significantly from brain to brain, at least in the terms of Ashby's interpretation of large numbers in Bremermann's argument.

So a teacher has, let us say (and purely for the sake of illustration), an order of magnitude of perhaps 1,000,000,000 states in his brain. (This figure is plucked from the sky.)

In a classroom (in the UK state education system), there are unlikely to be less than 30 students, all with more or less the same number of brain cells and potential brain states.

The combination of the number of states that the students have is $1{,}000{,}000{,}000^{30}$.

1,000,000,000 is 10^9, so the total number of brain states of the students in combination is

$(10^9)^{30}$.

This is 10^{270}.

This is not merely a transcomputable number, it is vastly transcomputable: 10^{270} is very much larger than 10^{73} or 10^{100} (choose whichever you like). In the Ashby/Bremermann sense it is so large a number, it so transcends the limit to the computable, that the transcomputability limit of all things material makes absolutely no dent in it. And it would be considered multiply transcomputable by Rauterberg's criteria. It is enormously vast: and it is enormously, inconceivably more than the size of the number of potential states in the teacher's brain.

(Actually, the dent that the limit of all things makes on this number is 0.000,000,000,000,000,1%. This is enormously more macroscopic than the tiny changes that generate chaotic behaviour, or than involved in homeostatic dilutions.)

Two things are now clear.

Firstly, the variety of a class of 30 students (the combination of the number of potential brain states) is absolutely vast (limitlessly Ashby/Bremermann transcomputable, according to our determination of the variety of a single brain's states).[5]

Secondly, the teacher has a worse than paltry variety in comparison to the variety of his class. According to the Law of Requisite Variety, he hasn't got the variety needed. He cannot possibly regulate his class properly. He simply hasn't the variety, there's nowhere he can get it from, he's nowhere near (so he can't fake it) and there's no imaginable way he manage without.

Robinson now makes the key point in his paper. It is to interpret the classroom situation that has still often been retained since the Victorian start of universal public education in the UK and elsewhere where arrangements are similar.

Since the teacher cannot gain variety, his only option seems to be to shut down the variety of the class. To understand how this has been done, just consider how the old-fashioned class was set up. Start with the classroom itself.

Everything possible is done to place the teacher in a position of authoritarian power (superiority) and to reduce interaction (and hence the combinations of states between students). The teacher faces the class, all of whom face him—square on. The teacher stands on a platform, above and overlooking the students, protected by his desk. The students are in the inferior position (and are obliged to sit, to emphasise this).

Then think of some of the rules of behaviour. Students must not talk until instructed to. The usual mechanism is for the teacher to ask a question (at a time that he chooses) and students to raise hands, leaving the teacher to invite one of the students in effect to speak for, or even as the class. Occasionally the teacher will fire a question "randomly" at a student of his choice. The students have absolutely no control over or equal participation in this process.

Students are also forced by the classroom design, and by its enforcement as a behavioural pattern, to all face the same way, towards the front. This reduces the risk of them talking together, which is anyhow enforced by rule. Furthermore, students are all dressed the same (in school uniform) and made to conform to very narrow limits of variation in appearance (Get your hair cut, boy!). They all work on the same task at the same time in the same way. It is almost as if the Victorians had discovered, studied and applied the Law of Requisite Variety to reduce the variety of the class, thus rendering the students controllable, more than a century before it was created. The effect is that the class has the variety of one person. The class's variety has been reduced by a combination of removing the effects of interaction (combinations) and treating the whole class as if it were simply one

[5] For another example which is Ashby/Bremermann transcomputable, consider the combination of materials in a single room. According to the architect Christopher Alexander, the number of possible (not actually existing, mind you!) combinations of chemical elements is 10^{30}. The combination of possible choices when there are 4 materials is, thus, 10^{120}. This far exceeds Ashby's limit to everything material. Do you know of any room with only 4 materials? No wonder there are problems in the Building Industry. Clearly the architect's job is impossible. Please remember that the next time you castigate him. You probably don't often intentionally handle anything like this complexity.

person. And, of course, the teacher is in the position of power (he can hold up to ridicule and punish, for instance).

Having completed this analysis, Robinson discusses ways in which the class could regain variety, thus enriching the learning experience and fighting for a more liberal and personally rewarding approach (such as small group self-teaching monitored by the teacher). For each of us has our own experience, and each of us has to offer what we have to offer.

Variety and Creativity

My interest, however, is different. It is creativity. Therefore, I shall now take leave of Ashby, Bremermann, Robinson (and Beer), and progress in a different direction. I am interested, as a professional matter in my life as a teacher of architecture, art and design, to see if it is conceivable that, through some teaching arrangement, I might in principle be able to enhance the creativity of students.

Actually, I'm not quite that ambitious (or foolhardy). Creativity is a scientific can of worms. How on earth can it be shown that creativity, of all things, has been enhanced? What does creativity mean, anyhow, and how could it (and enhancement) be measured?

I choose a simple way out. I am going to assert that what I'm looking for is an increase in the variety of possibilities within which we can operate as (creative) people. I assume, as a matter of faith (I cannot prove it and I make no attempt to but it is the accepted "Wisdom of the Enlightenment"), that an increase in the variety of possibilities will lead to an increase in creativity. I am prepared to accept that this may not always be so: people may become overawed by the riches and choices, and there may be times that a reduction in this variety, focusing intensely on something very particular, will be the more enriching way. But to say there are important exceptions and particular cases does not take away from the general position, a position that is probably held by almost everyone who teaches in "creative" areas.

I argue the basis of this position in my paper "Variety in Design", where I argue for the benefits of sharing and co-operation in design (common practice) as a way of increasing available variety, and for us to learn to use computers not so that we control them as tools that carry out our will, but so that they both facilitate sharing and are used to generate surprise, thus also increasing the variety available to the designer.[6]

Behind this a more important concept lurks. It has to do with how we treat an imbalance in variety, when we find that we have less than the system we are interacting with and which we have, traditionally, handled by closing down the variety of the system to be regulated, so that we can control it.

The Value of Unmanageability

[6] I have been attending conferences concerned with computer aided design for many years, now, preaching this message in various forms. Slowly my approach to the computer, that it might generate things we are not capable of if we tried to converse with it instead of commanding it begins to be replayed to me by others, although rarely with references and credit! There is hope yet.

Twelve Step Programmes such as that of Alcoholics Anonymous, as part of their first step admitting addiction, add the rather strange phrase:

> …our lives had become unmanageable.

Why on earth is this tacked on? And what has this to do with Cybernetics, or even Human Learning?

Unmanageability is, of course, a cybernetic concept. Indeed, that is exactly what was considered the central notion of cybernetics—at least until the development of second order cybernetics. Or, rather, it is what cybernetics was not about: cybernetics tried to avoid unmanageability at all costs. That was its subject: how to make things manageable. Indeed, the Law of Requisite Variety is specifically aimed at checking that systems are controllable by those that might be trying to control them.

We can also argue that with a closed mind (world), it is hard for us to learn: that learning involves accepting states outside of those we already have, which are, therefore, in a sense unmanageable.

So, in Robinson's example of the classroom (above) the teacher in the traditional arrangement went to some lengths to avoid the potential problems of not having enough variety to control the class, of the class becoming unmanageable. He reduced the variety of the class until it was the same as his.[7] In this way, he could control it, stop it becoming unmanageable. It is this mechanism that gives control a bad name—when control is not regulation but restriction.

My proposal is exactly the contrary. If we want to enhance our creativity, then we need to gain options (variety). We can gain variety wherever we find in our environment more variety than we find in ourselves, so long as we are open to that variety and do not try to control (i.e., restrict) it. When we are faced with unmanageability we have opportunity: opportunity to find more variety than we currently have. We can borrow from others, from the environment, from the serendipity of accidents and the surprising synchronicity of events; sharing and "colonising" the environment. (And we can also improve our own performance by designing more variety into our brains.)

This state of affairs is what is called, in conventional terms, unmanageability. It has been taken to be a bad thing. But the truth of the matter, if my analysis is correct, is that it is not bad at all and is to be welcomed.

As an example, think of the internet. The internet is, thankfully, uncontrollable even by the US Government. When we enter into interaction with it (we know not if we interact with computers or people, by the way, so it passes the Turing intelligence test) we are confronted with uncontrollable unmanageability, a

---

[7] In Ashby's formulation the controlling system must have at least as much variety as the controlled. However, as I have explained in earlier columns, the advent of the recognition of the circular control that is central to second order cybernetics makes the controller and the controlled mutual and relative: ie the controller is controlled, itself, by the controlled. That means the variety, to satisfy the Law, must be identical in each system.

complexity of variety that it is beyond our ability to calculate. We interact with it in one of two ways. If we know what we want, we reduce the effective variety of the internet so that we restrict it to focus just on our demands. If we are surfing, we just go with the flow. We have no idea where we will go: the environment, and particularly our relationship with it, is unmanageable. If we use this unmanageability well, we discover all sorts of novelty and become more creatively empowered. We are endlessly surprised.

Our interaction with the internet has a life of its own: it is (like) a conversation.[8]

The truth of the matter is that, when we treat the world as constructed, in the manner in which the Law of Requisite Variety, and its measure—variety—invite us to take the world, the world facing each and every one of us is unmanageable. The world has vastly more variety that any one of us can dream of having. Indeed, the world we construct must be massively transcomputable.

This means that we are left with two options. To try to control the world by reducing its variety (leading to a very restricted and normative life), or to go with it, accepting that it's beyond our control and enjoying the novelty it offers us through its variety.

It is these two choices that I believe Twelve Step Programmes' first steps are about. Addicts are (as are many other people) controllers, and have to learn not to control. The world (when we take a quasi-realist view) is vastly complex. Try to reduce its variety and there will be surprises (failures) which will be hurtful and difficult. The same lessons are taught us by (at least many) religions. They require tolerance, humility (not insisting on being right or getting your own way) and opportunism. And they give us surprise, delight, a roller-coaster of a life and a better chance to be constructively and positively creative.[9]

Variety and creativity are, in this interpretation, connected. The more variety there is available to us, the more creative we are likely to be. So long as we let it remain unmanageable, and don't restrict the variety available to that we have.

Maybe this inversion is the sort of inversion that powers second order Cybernetics, and which we can use to generate new understandings of precisely the type this column is addressing!

References

Anonymous (1939): *Alcoholics Anonymous,* New York, Alcoholics Anonymous World Services.
Ashby, R (1964): "Introductory Remarks at a Panel Discussion" in Mesarovic, M (ed) *Views in General Systems Theory,* Chichester, John Wiley and Sons; (also to be found in Klir, G (author and ed) "Facets of Systems Science", New York and London, Plenum Press.
Beckett, S (1959): *Molloy*, London, John Calder.
Bremmermann, H (1962): "Optimisation Through Evolution and Re-Combination" in Yovits, M, Sawbi, G and Goldstein, G (eds): *Self-Organising Systems,* Washington DC, Spartan Books.

[8] For a developed argument about the nature of such interaction, see my "Acts Between and Between Acts".

[9] Of course, dictators are amazing examples of variety reducers—controllers in the restrictive sense. In contrast, the motto of the British Royal Family ("Ich dien", I serve) is much more sympathetic and liable to work for a ruler, at least in principle.

Glanville, R (1994): “Variety in Design”, Systems Research vol. 11 no. 3

Glanville, R (in press): “Acts Between, and Between Acts”, Proceedings of Consciousness Reframed ’98 Conference, Newport 1998.

Glanville, R (in press): “The Value of being Unmanageable: Variety and Creativity in CyberSpace”, Proceedings of the Global Village Conference, Vienna 1997.

Rauterberg, M (1997): “Activity and Perception: an Action Theoretical Approach”, presented at the Conference on “Problems of Action and Observation”, Amsterdam 1997 (to appear in the Proceedings edited by Glanville, R and de Zeeuw, G, published by BKS, Southsea).

Robinson, M (1979): “Classroom Control: Some Cybernetic Comments on the Possible and the Impossible”, Instructional Science vol 8.