ONLY BEHAVIOUR CAN DESTROY BEHAVIOUR

A useful behavioural interpretation of Ashby?

James Bryant
Camberley, United Kingdom
James.bryant@requisitebehaviour.com

ABSTRACT

Currently, we find ourselves with insufficient remedy to the way we behave towards each other and the planet and are in desperate need of unlocking, conceptually and practically, the creation of a better behaving world.

One potential source for such an enlightenment is Cybernetics.

This paper proposes a behavioural model based on displacement and control, derived from a critical examination and development of Ashby's Law of Requisite Variety presented in *An introduction to cybernetics.* This outcome is that *Only Behaviour can destroy behaviour* and the Laws of Requisite Behaviour:

1. A system experiencing a force that might displace it responds by generating a behaviour
2. The purpose of the behaviour is to enable the system to continue to pursue its intent
3. A displacement is always the result of a behaviour, and a behaviour always causes a displacement.
4. That behaviour may be to adjust the intent so that it may continue to be pursued
5. Intents exist in a hierarchy and less important intents will be abandoned in favour of more important intents if required.

Hiding in plain sight within *An introduction to cybernetics* (Ashby, 1956) is that cybernetics is about the behaviour of machines:

> *Cybernetics, too, is a "theory of machines", but it treats, not things but ways of behaving. It does not ask "what is this thing?" but "what does it* do?" (p. 1)

When Ashby considers biological organisms, he is most concerned with survival, and on the act of blocking communication:

> …*the concepts of "survival" and "stability" can be brought* into an exact relationship… (p. 197)
>
> In general, then, an essential feature of the good regulator is *that it blocks the flow of variety from disturbances to essential variables*. (p. 201)

Ashby's application of cybernetics to human behaviour is only explicit in explaining human behaviour when it parallels the regulation of a machine. However, placing Ashby's 'ways of behaving' as the central tenet provides the basis for an evolution of Behavioural Cybernetics.

This Behavioural hypothesis presented here considers disturbance to generate Requisite Behaviour: the behaviour needed to control displacement to an extent that enables the organism to achieve its intents.

Variety of behaviour arises from a strategy of variable regulation towards displacement that ranges from zero to full control: 'blocking' is not the only successful strategy for survival. This is supported by research and observation from disciplines, including biological, behavioural and social sciences.

It is expected that subsequent papers on Requisite Behaviour will reveal new and much needed insight into the use of this interpretation of Cybernetics to effect change in human systems behave better: the requisite behaviour to achieve a better behaving world.

Keywords: Behavioural, Behaviour, Cybernetics, Variety, Requisite, Equilibrium, control, Displacement

INVESTIGATING THE LAW OF REQUISITE VARIETY (LORV)

The Law of Requisite Variety is an elegant expression of the concept of duality in which a system consists of two opposite parts in continuous tension. This concept has been examined throughout human history from the earliest times and remains of contemporary interest in a wide range of disciplines. Whilst it is the foundation stone of cybernetics, it is of significant interest in others, for example biology, in which Robustness (survivability) is affected by Perturbation (exogenous or endogenous factors that increase disorder within a specified system) (Flack, J.C., Hammerstein, P., and Krakauer, D.C. 2012).

In Cybernetics Ashby, (1956) conceived 'disturbance' as 'that which displaces'; that which moves a system from one state to another' this force being countered by control. When the two are matched the system is maintained in equilibrium. Ashby notably stated that (only) 'variety can destroy variety'; that is to say that a system will lose its equilibrium unless the variety of disturbance that is able to cause displacement is matched by an equal variety of control. For clarity, each cause of displacement must have an opposite force able to control it.

I shall begin by examining these two concepts.

Disturbance and control

What do you call the force that doesn't displace? Is there such a thing?

If we consider a breeze, it may displace a dandelion clock but not a person.

The ability of the breeze to displace is dependent upon the system and its strategy to the potential displacement. That dandelion clock has evolved a design that is 'intended' to be displaced, whilst any possible displacement is nullified by the human.

Applying Ashby, the dandelion clock possesses insufficient variety and the human sufficient variety. The dilemma arises that, in the human example, because zero displacement occurs the breeze is not a disturbance and ceases to exist as such. This makes the existence of disturbance dependent and determined by reference to the system to which it applies.

It is preferable to consider the existence of the breeze as independent, which requires a change in terminology; to drop the term disturbance and substitute instead the term Potential Displacement Force (PDF). This confers us with the ability to describe and consider all forces as having the potential to displace and the behavioural outcome as a response to that attempted displacement.

Applying Ashby's LORV, the ability of a PDF to displace is reliant on its variety, that being the number of unique elements of its composition. For example, a breeze will have at least speed, humidity, and direction. We will think of these unique elements as units of variety (U).

However, displacement is not caused by uniqueness but relies upon the force it is able to direct on the system to displace it: this is a vector of displacement that I will give the term D. Combining the two terms into a single term UD deliver a unit of variety that has potential to displace. Therefore, the PDF is composed from Units of Displacement, each and with a unique vectors n, and can be described by sum $UD_1 + UD_2 \ldots UD_n$ and thus

$$\sum_{i=1}^{n} UD_i$$

Using such an approach we can classify 'wind' as a Potential Displacement Force on a continuum from a light breeze to a tornado by considering the vector value of each of the Units of Displacement.

For example, consider a tropical storm. This macro phenomena requires the following conditions in its compound variety:

- High sea temperatures of at least 27°C.
- Converging winds near the ocean surface forcing air to rise and form storm clouds.

- Winds that do not vary greatly with height - known as low wind shear. This allows the storm clouds to rise vertically to high levels.
- Sufficient distance from the equator for a spin such as the Coriolis force to take effect.

It is self-evident that its occurrence is dependent upon each of its units of displacement simultaneously achieving the requisite ‘conditions’ (vector values). It likewise follows that preventing such a phenomenon arising would be achieved by preventing the requisite conditions from being achieved.

This aligns with Ashby (1956) who identifies that Disturbance (in our terms ‘a displacement’) can be a compound Vector, i.e. formed from a variety of components.

Now let’s turn our attention to control and the behaviour of the system that experiences the PDF.

The system subjected to the PDF generates a behavioural response that can be described as the Potential Controlling Force (PCF). This a mirror of the PDF, being composed from units of variety (U) each having a vector of control C, which is expressed as UC (Unit of Control).

It also follows that PCF is the aggregate force of all vector values n, described by sum UC_1 + UC_2 …UC_n.

$$\sum_{i=1}^{n} UC_i$$

Derived from Ashby’s LORV, when the system seeks to remain in equilibrium it must counter *possible displacement* to maintain control, achieving a balance when the displacing units within the PDF are balanced by equal and opposite units of control in the PCF.

For convenience I will assume that when we talk of PCF and PDF it is these active units that we are considering and so equilibrium can be expressed as $PDF = PCF$

For clarity, Equilibrium actually means that the system continues to operate to pursue its intent in a manner that is unaffected by variation in the context within which it exists. This can be considered a strategy, but as will be shown is but one strategy that the system can adopt.

Applying Ashby’s LORV, it follows that Displacement occurs when $PDF \neq PCF$.

Visualising the Law of Requisite Variety

Visualising the above produces Figure 1:

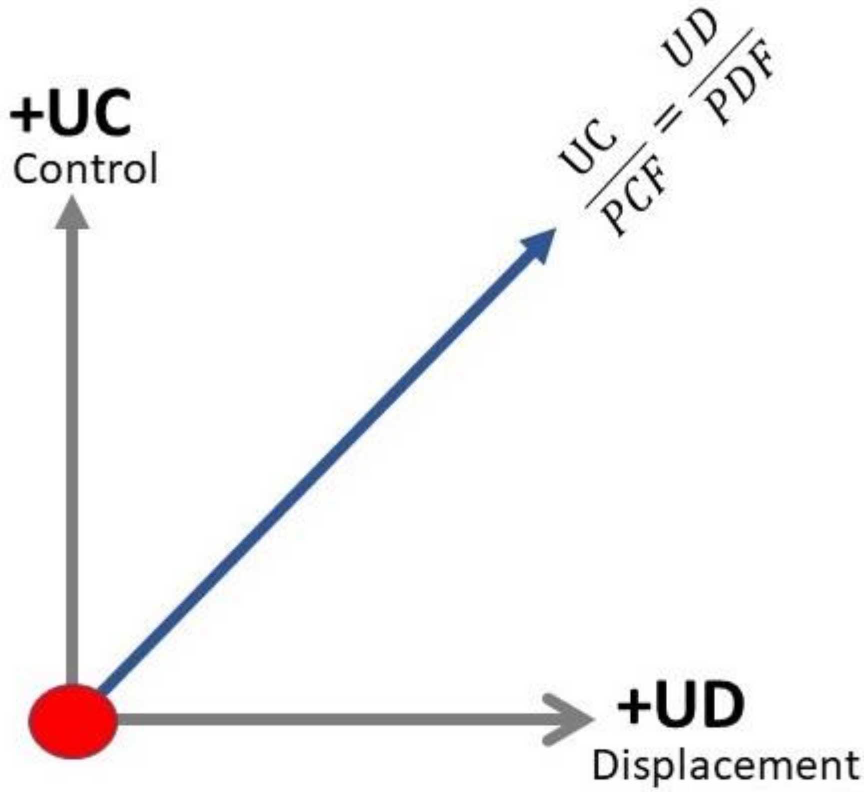

FIGURE 1 ASHBY'S LORV

The red ball represents a system.

The vertical axis represents units of control and the horizontal axis units of displacement.

The forces of displacement are envisaged as attempting to move the red ball horizontally and the units of control exerting a force vertically.

When the forces are balanced the system remains in control (equilibrium) and is able to continue to pursue its intent or execute its intended purpose; the red ball moving backwards and forwards along the diagonal arrow (equilibrium line) as the units of displacement rise and fall due to changes in the PDF and subsequent compensating changes in the PCF.

To be explicit, this only considers the units of displacement from the PDF and the units of control from the PCF that have an effect on the system. This is represented by the equation:

$$\frac{UC}{PCF}$$

It should be considered that in moving along the line through exerting control the energy state of the system may change as exerting control may require energy and resources to be deployed to counter the displacement.

Figure 1 implies the ability to exert infinite control whilst, in reality, systems have upper and lower limits of tolerance for displacement, and such a bounded system is shown in Figure 2.

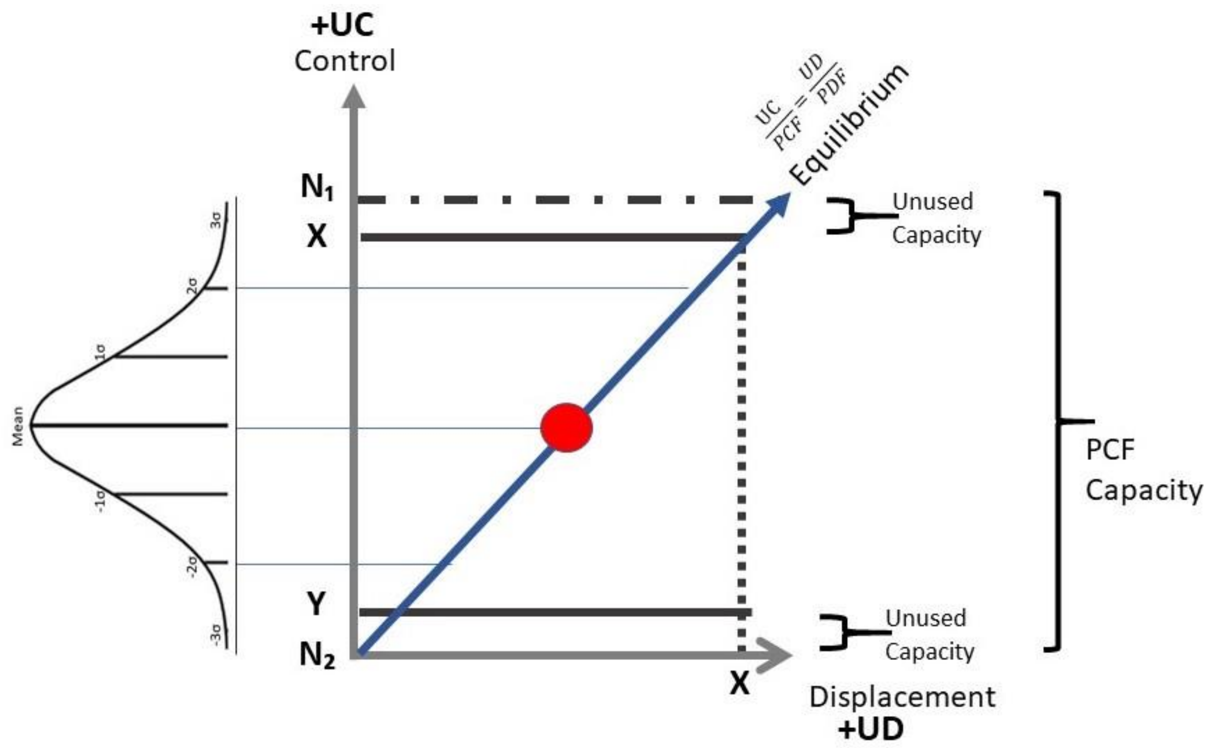

FIGURE 2: NORMAL CONTROL WITH LIMITS

In this figure the upper limit of control is shown as N1, the lower by N2 (which is zero) and the total PCF capacity equal to N1 – N2. X represents the normal upper maximum and Y the lower minimum of the range of behaviour.

Assuming the behaviour of the system is 'normally distributed' we can apply the normal distribution curve to identify the 'time spent' in various positions along the equilibrium line. It can be considered that the upper limits, in the case drawn, beyond 3 standard deviations from the mean, is unused capacity. It is worth noting that the resilience of a system might be measured by the relative size of its unused PCF capacity.

This demonstrates limits of control. Beyond the upper and lower limit, the system fails to be able to maintain an equilibrium and therefore fails to be able to deliver its intent. However, there are issues with this model:

1. At the lower limit, when the control and displacement are zero, it is impossible to distinguish between a system that is operating and one that is switched off except by measurement of its activity in pursuing its intent.
2. Arguably no system, but beyond doubt no living system, is ever free from the forces of displacement.
3. The model relies on being able to identify all units of control and displacement to position the equilibrium relative to zero.

For these reasons, the model can be improved on by introduction of the concept of relative units of control as shown in figure 3. Relative control and displacement are denoted by the use rUC and rUD from hereon.

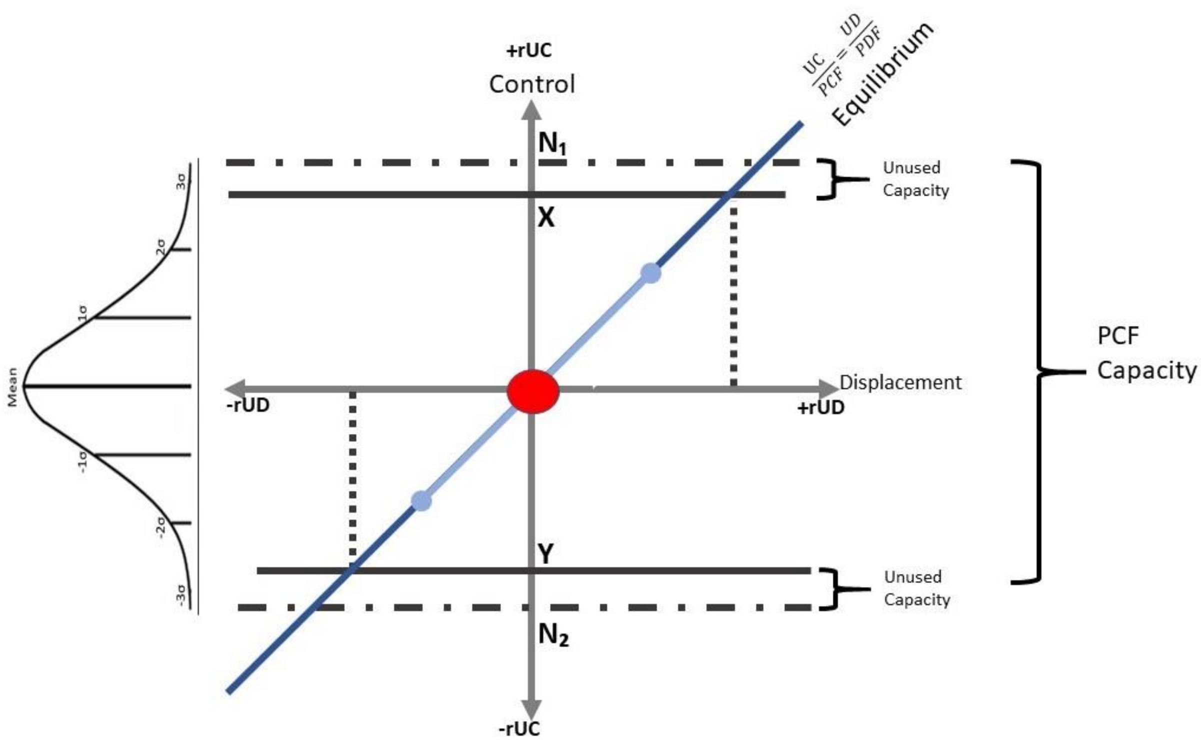

FIGURE 3: RELATIVITY MODEL OF DISPLACEMENT AND ITS CONTROL

Figure 3 represents exactly the same system as Figure 2, however the axes have been moved to centre at the middle of the normal curve and the units changed to be *relative* units of control and displacement, denoted by the use rUC and rUD.

This enables the system to be calibrated on what is observed, measured or agreed as permanently or temporarily ‘normal’ behaviour and any change to be relative to it: more or less than normal. This Einsteinian concept of relative change is worthy of further exploration but lies outside the focus of this paper.

The upper and lower limits remain and are again relative and so the lower limit of control is defined not as zero control but as a point at which the difference from normal is so great that it falls outside the capacity of the system

The detailed behaviour involved in maintenance of an equilibrium shown in figures 4 and 5. Figure 4, illustrates that the equilibrium line represents the centre of a dynamic state of tension between the forces of displacement and control. When the two forces do not instantaneously cancel each other out, displacement will occur and then be corrected (illustrated by the red arrow), the time taken for this to happen being dependent on the speed of the system's response.

It is obvious that the lag between displacement being experienced and being controlled critically affects the stability of the equilibrium and it can be anticipated that the response time will vary dependent upon the nature of the units of displacement.

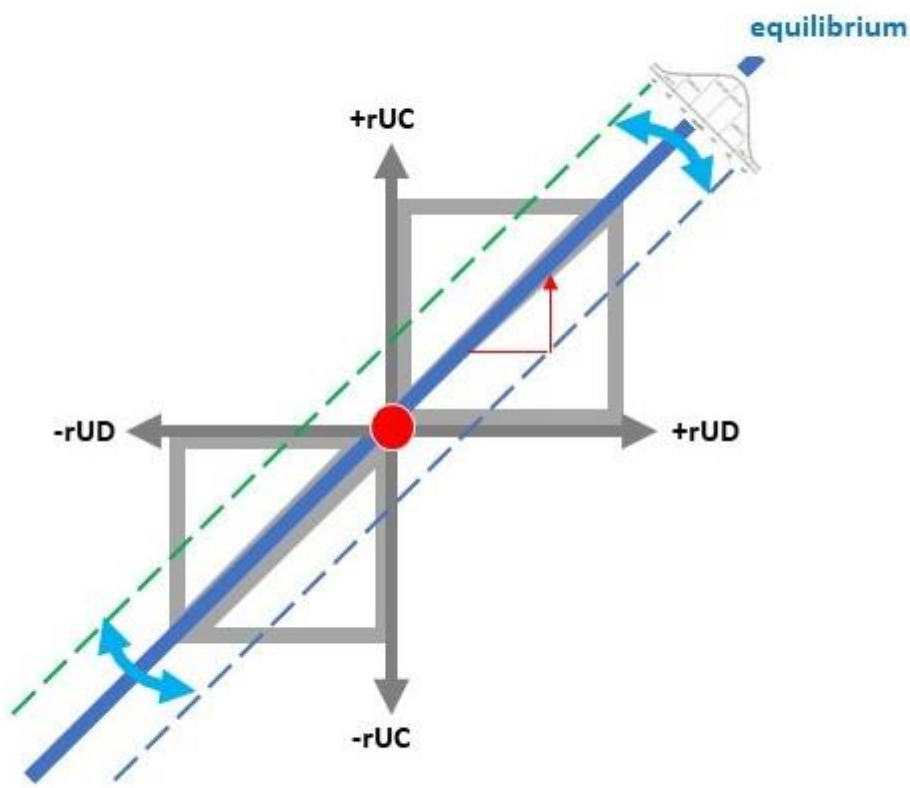

FIGURE 4: DYNAMIC EQUILIBRIUM

A cut across the equilibrium line at a point in time is shown in Figure 5A. It shows that taking a snap shot at a point in time, one would observe the state of the system (red circle) at a position somewhere between the centre of the equilibrium line (blue circle) and the outer limits of normal behaviour: the maximum displacement before correction. This has parallels with the Rubber Band Demonstration of Control and Conflict used in PCT.

Figure 5B shows a cut along the equilibrium line to show the path of the state of the system over time and how it may be in continual flux.

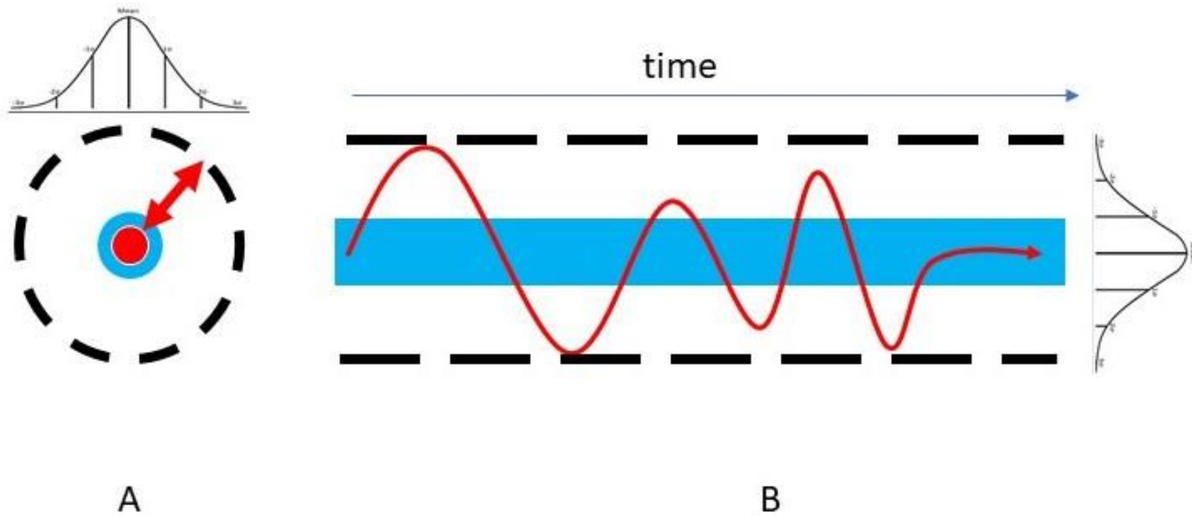

FIGURE 5: DYNAMIC EQUILIBRIUM: FLUCTUATIONS WITH TIME

From this examination, it is evident that response time is part of the control system and should be considered as part of the vector value for both displacement and control.

The shift to a relativity model highlights Ashby's focus on the domain of the equilibrium line and its hinterland. It raises questions as to whether the strategy of maintaining equilibrium is the only strategy to displacement? Whilst a state of equilibrium seems inherently the most desirable state for mechanical systems, is it also true for biological systems? It raises the question: 'Do biological systems maintain or use imbalanced states?' These would be represented by the behaviour of systems that can be defined by the equations $PDF \neq PCF$ and $\frac{UC}{PCF} \neq \frac{UD}{PDF}$.

Earlier I mentioned that the Dandelion Clock has evolved a design that is 'intended' to be displaced as anyone who has ever given one hard blow will have witnessed. This seed head is designed such that any wind of sufficient strength will break its structure and carry away its seeds. This alone is evidence that biological systems deploy strategies other than maintenance of equilibrium and therefore the non-equilibrium space is worthy of further explorations.

This would be of no surprise to Ashby (1956) who explicitly anticipates that stability and equilibrium are simplifications, compound, and that complexity may require the user to 'be prepared to delete them and to substitute the actual facts, in terms of states and transformations and trajectories, to which they refer' (p. 85).

THE LAW OF REQUISITE BEHAVIOUR

The response of mechanisms to Potential Displacement is limited by their designed-in control variety and, if displacement is not fully attenuated, the state of the mechanism changes and will eventually fail when limits of control variety are exceeded.

In contrast, whilst biological systems have a requirement for ‘stability’ they also require and seek out unstable states. They are also more complex, having multiple intents operating at the same time. Whenever possible, they respond to displacement with behaviour that exerts variable control determined by what best serves the achievement of these intents. Unlike classical mechanisms, for some biological organisms the ultimate limitation on control variety is not their physical design, but their ability to exercise creativity, to develop new controls when encountering new forms of disturbance. In these organisms the ability to develop new Requisite Behaviour is the constraint on their ability respond to disturbance. It is self-evident that all response mechanisms are behavioural: a behaviour is required to exert control, which we can describe as ‘Requisite behaviour’.

In biological systems, this ‘Requisite Behaviour’ may also include adaptation of the intents to the prevailing internal and external context by modification, variation, substitution, addition and deletion of intents. This may be considered as second order behavioural cybernetics. (As used here, Context and Potential Displacement Force are interchangeable terms.)

Requisite Behaviour can be considered as the deployment of strategies that lie on a continuum between total change and no change, providing the regulation required for the intent of the system to be performed.

The complete regulation of displacement so that its effect is nullified is represented by Ashby’s Law of Requisite Variety, however he anticipated different states of equilibrium:

> All the states of equilibrium—stable, neutral, and unstable (Ashby, 1956, p. 78)

If we consider potential displacement force as the behaviour of the context, and displacement as the force that emerges from the context to affect the system unless it is controlled, we can define the behaviour of biological systems, in the style of Ashby, by the Law of Requisite Behaviour:

Only Behaviour can destroy behaviour

In the same way that behaviour may be considered by some as implicit in variety, variety is implicit in behaviour. However, by making behaviour explicit and the focus of our attention, it provides a new position from which to observe and investigate Cybernetics that must have utility, based on the well understood importance of the position of the observer in all branches of science.

This is supported by the findings and conclusions of Stanley Milgram who, as a result of his experiments into behaviour subjected to the displacement of authority, stated that the major lesson from his experiments was that ‘it is not so much the kind of person a man is as the kind of situation in which he finds himself that determines how he will act’ (Milgram, 1974)

BEHAVIOURAL EQUILIBRIA: STRATEGIES TO DISPLACEMENT

If we consider Human behaviour as a response to displacement it provides a new understanding and method of modelling behaviour.

Based on the model proposed, there are four main strategies that can be drawn, shown in figures 6-9. Whilst recognising there are many possible nuanced variations.

The proposal that biological organisms use these other states of equilibrium can be tested against these ‘equilibria’ by evaluating them against their ability to explain observed behaviour. Should they be identifiable and prove useful, it may be concluded that they exist, and that the hypotheses presented in this paper have validity.

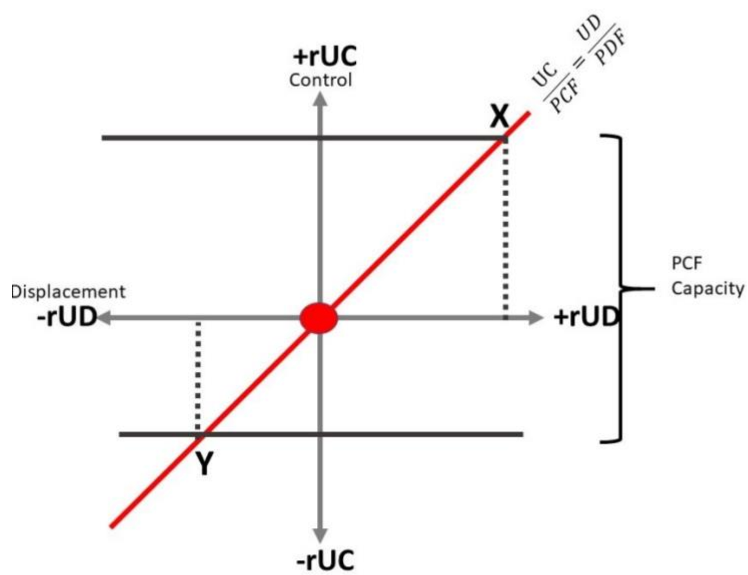

FIGURE 6: BALANCED EQUILIBRIUM

This is the form already discussed at length where the system establishes a perfect balance with the PDF. This organism continuously adjusts its activity in line with fluctuations in the external forces it experiences. The operation of this equilibrium is not in question, it is the basis of regulation in living organisms, from internal systems like homeostasis in mammals to external behaviour like the moderation of behaviour by fresh water fish dependent upon the level of dissolved oxygen and water temperature.

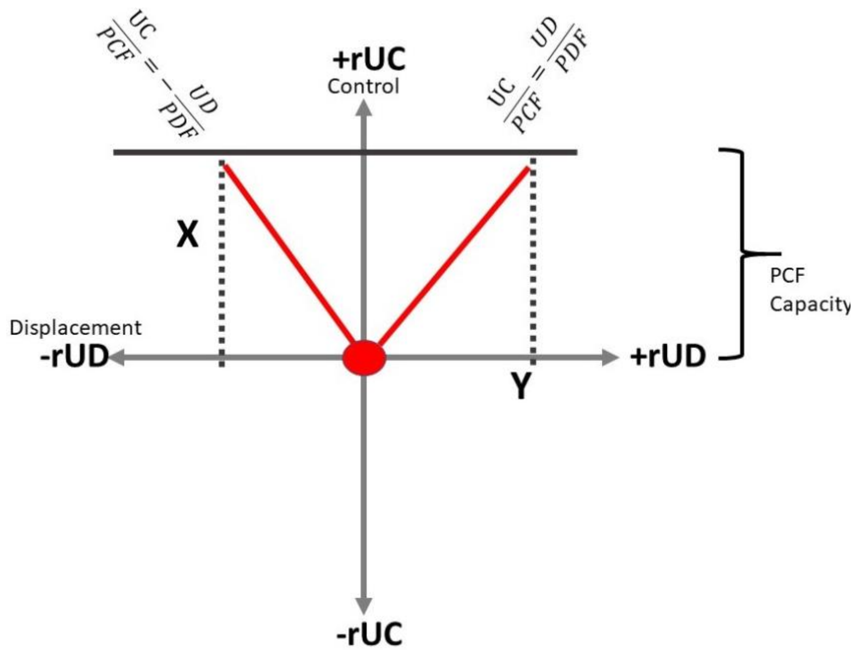

FIGURE 7: ROBUST EQUILIBRIUM

This Behavioural Equilibrium is highly stable. When relative displacement decreases the organism increases its relative control, for example by planning and preparing and building reserves, increasing its resilience against expected displacement; when relative displacement increases, it counters it to maintain a balance.

This characterises people and organisations that are stable and robust under normal circumstances: they resist change and when things get ‘easier, redirect their efforts to increasing their robustness.

This organism is continuously energetic in resisting change and is represented by any resident organism that builds its home and breeds when times are easy, and works hard to stay alive when times get tough. A polar bear might be considered as characterising this behaviour as it does not hibernate having physiological adaptations that enable it to remain in the harshest environment.

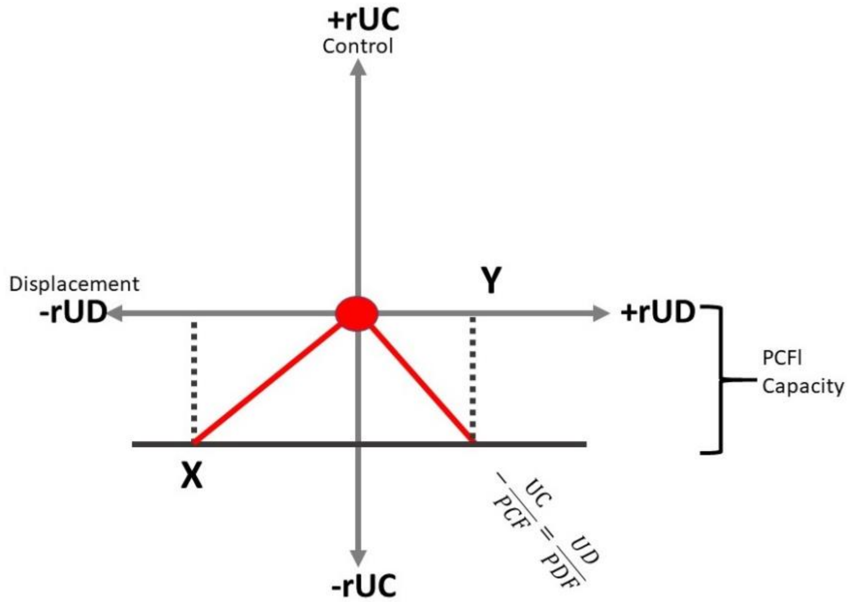

FIGURE 8: DISENGAGED EQUILIBRIUM

This Behavioural Equilibrium stays in balance when relative displacement decreases but is out of control when relative displacement increases: in other words, it is displaced.

Displacement may be positive or negative with death and extinction being the ultimate example where insufficient variety exists to prevent it. However, organisms can also be observed to use or adapt to displacement.

On the one hand, all air borne pollination, the dandelion seeds on the wind, can be considered as using relative displacement; when the wind is at a normal level it isn't displaced and when it increases it 'allows itself' to be displaced.

Species that migrates, for example geese migrating south away from the winter snow, can be considered to have developed a behavioural response due to their inability to exert sufficient control to remain in the environment (compare the polar bear above).

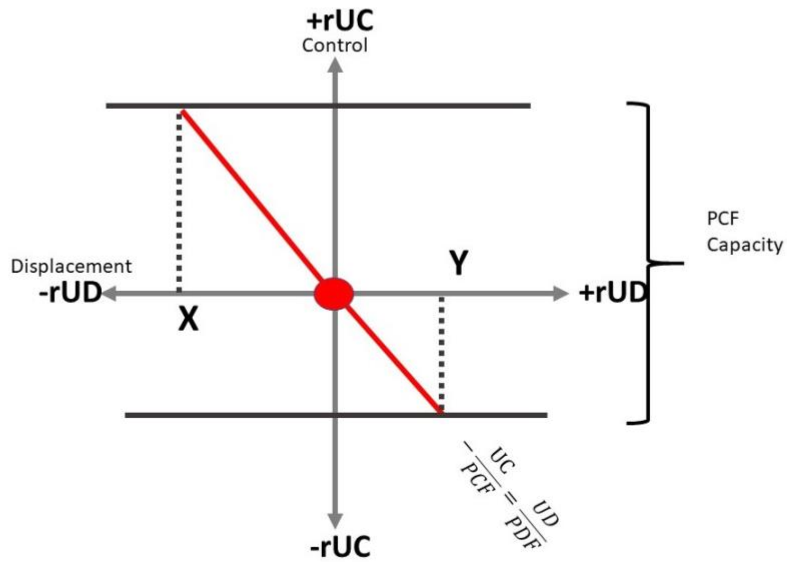

FIGURE 9: PROGRESSIVE EQUILIBRIUM

In this strategy, relative control increases when relative displacement decreases and this can be considered as'planning and preparation' however when relative displacement increases the system does not exert control but reduces it, 'allowing' itself to be controlled.

In human beings this could be considered to represent a nomadic existence, being displaced to areas of greater abundance where relative displacement is lower and greater relative control can be exerted.

It may also be considered to characterise a brown or black bear eating its fill and building up its body mass and then hibernating for the winter.

SUMMARY

These various equilibria are recognisable in biological behaviour and a little further consideration exposes that many of these equilibria are deployed in parallel by an organism. For example, whilst the pollen is displaced by the wind, the tree is not. Therefore, we can consider that organisms are composed of multiple 'equilibria' each adopting a behavioural strategy appropriate to achieving its specific purpose.

I began with an examination and visualisation of Ashby's Law of Requisite Variety and proposed that displacement is a behaviour which is responded to by control behaviour.

It was then proposed that when Ashby's Law of Requisite Variety is applied to biological systems that the concept of 'variety' may be replaced by 'behaviour' and consequently, the Law of Requisite Behaviour was derived and stated as: 'only behaviour can destroy behaviour'. This gave rise to the concept of Requisite Behaviour: the behaviour needed to control displacement so that the organism is able to achieve its intents.

By moving from a model of Ashby's LORV using absolute measurement to one of relative measurement, and by the introduction of units of displacement and control, four Behavioural Equilibria were identified: these different behavioural strategies are created by destroying differing amounts of displacement. By reference to examples of actual behavioural strategies that match these hypothetical models, they were demonstrated to be real.

As a consequence, and to summarise the content above, the Law of Requisite Behaviour (Only Behaviour can destroy behaviour) can be expanded to provide the Laws of Requisite Behaviour:

1. A system experiencing a force that might displace it responds by generating a behaviour
2. The purpose of the behaviour is to enable the system to continue to pursue its intent
3. A displacement is always the result of a behaviour, and a behaviour always causes a displacement.
4. That behaviour may be to adjust the intent so that it may continue to be pursued
5. Intents exist in a hierarchy and less important intents may be abandoned in favour of more important intents if required.

DISCUSSION

Every mechanical system is limited in the variety it can possess due to its design: that is to say that the variety in a system has a capacity. However, in biological systems the ability to create and learn enables new behavioural capacity (variety) to be developed (adaptation) in response to changes in context. Therefore, in biological systems the 'free' capacity is dependent upon the behavioural plasticity of the organism: the ability to devise or adopt new or alternative behaviour.

In biological organisms, capacity must also consider the ability to generate behavioural responses (strategies) that enable the intent of an organism (e.g. survival) to be achieved by co-operation, where alone it would not. For example, penguin huddling.

Capacity may also be lost from biological systems that shed unused variety, both physiological and behavioural, over time. For example, if when the variety of experienced relative displacement reduces and relative free capacity increases, the system responds by reducing units of control (figure 6) variety is reduced. For example, the evolutionary loss of the appendix in humans. Putting it simply, use it or lose it. Ashby describes that as time progresses there will be a decay of variety (in machines) which he summarises as the Law of Experience: changing a parameter tends to destroy and replace information about the systems original state (Ashby, 1956, pp. 137-139). It should be noted that contrary to this, human beings are known to portray a persistence in repeating behaviour (retention) that is ineffective or even harmful.

These are just some of the differences between machines and biological systems, and perhaps between traditional machines and emergent AI, to which a Behavioural Cybernetics can be applied.

Previous writers have noticed and commented on the relationship between behaviour and cybernetics, and so the value is not in complete novelty but in the novelty of the focus and the usefulness that arises from it. Investigation of what is in plain sight sometimes yields useful understanding: like when Newton noticed what everyone already knew, that things fall, and got a bit interested in why!

So, this paper has begun to develop a focused body of thought around what I have boldly termed 'Behavioural Cybernetics': Cybernetics that considers displacement and control explicitly and solely to comprise of behaviour, summarised by the statement *Only Behaviour can destroy behaviour* and represented by the 5 Laws of Requisite Behaviour. Since the purpose is to enable the development of Requisite Behaviour that may enable progress towards achieving a better behaving world, it is my intention to expand on the concept of Requisite Behaviour in further papers to develop a deeper understanding of its dynamics with the aim of devising tools, models and processes that provide utility in understanding and changing behaviour. This work is underway.

The author is mindful that, based on the paper by M. C. Jackson (1988), there are both useful parallels and significant differences between Beer's work and the work in progress, and that these require elucidation. For the concepts here to be compared with Beer requires a comparison of systems, which in turn relies on publication of my work in progress which is developing such a system. When that is able to be published, such a comparison will be included.

However, the expected outcome is that independently they will provide significantly different cybernetic approaches to the management and change of human behavioural systems, and perhaps if used in conjunction, they will provide a combined solution of even greater variety and efficacy.

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