Cardioid Attractor Fundamental to Sustainability

8 transactional games forming the heart of sustainable relationship

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Introduction
As explored in an associated paper (Being Positive Avoiding Negativity: Management challenge -- positive vs negative, 2004), exhortations and injunctions to "be positive" are a common feature of some religious groups, in the development of selling techniques, in self-help therapies, in work group development, and in living with potentially fatal illnesses. These are seen as a means of avoiding or defeating negativity in those different contexts [more]. Here the focus is on highlighting the existence of a set of games, rather than a single game, that potentially are all aspects of a sustainable cyclic system that merits further attention.

The paper explores, in the light of a general systems perspective, the possibility that this sustaining cycle can be understood in terms of the Carnot heat engine cycle and the Coaction Cardioid cycle of Edward Haskell (1972), further developed by Timothy Wilken (2002). It also explores whether any such generic cycle, relating "positive" and "negative" conditions, can also be related to the conditions identified by the Taoist Ba Gua mirror, and notably as a reflection of the cycle of processes described in Taoist spiritual disciplines.

Interrelating positive-negative hybrids
It is very likely that it will prove fruitful to distinguish between several forms of "positive" and "negative" -- to recognize valid concerns but to avoid collapsing valid distinctions. A helpful pointer is provided by Edward Haskell (Generalization of the structure of Mendeleev's periodic table, 1972) in his work on the coaction cardioid (see below), as introduced by Harold Cassidy. Cassidy points out that:

In the cybernetic analysis of the more complex and organized systems we recognize two distinct kinds of factors. There is the work component or components, which we shall designate X, and the governor, or controller, which we shall designate Y. Of course, the governor does work too (the strategic work), and we have simplified the relationships very greatly. There will be
cases of a system made up of sub-systems, one controlling in some respects, not in others, and so on. Let us stay with the simpler case. Now, the processes that characterize X may, in the interaction with Y, be accelerated or in some way enhanced (+), or may be unaffected (O), or may be decreased (-). Similarly, the processes that Y undergoes. When the possibilities are cross-tabulated, it becomes evident that there are nine and only nine of these qualitatively different 'coactions.' [glossary]

Haskell applies this insight to a range of systems, notably in the natural environment (in Figure 1) but also in the social environment. In the case of the different kinds of relations between animals in an ecosystem, the following patterns then emerge-- of which 8 of the 9 are non-neutral. Note that there are variations in the terminology of biological interaction, notably differing from Haskell's usage [more | more]. The dynamics of each of the 8 relationships might be described as a "game", however asymmetrical or predictable the outcome (as with the "cat-and-mouse" game of predation).

**Figure 1: Possible 8-fold Positive-Negative Hybrid Conditions**

<table>
<thead>
<tr>
<th>X = &quot;Work component&quot;</th>
<th>Y = &quot;Control component&quot;</th>
<th>Positive</th>
<th>Neutral</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>predation</td>
<td>(positive negativity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>amensalism</td>
<td>(neutral negativity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>synnecrosis</td>
<td>(negative negativity)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Neutral</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>allotrophy</td>
<td>(positive neutrality)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(neutral neutrality)</td>
<td>(neutral neutrality)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>alopathy</td>
<td>(negative neutrality)</td>
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<td></td>
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<tr>
<td><strong>Negative</strong></td>
<td></td>
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<tr>
<td>parasitism</td>
<td>(positive positivity)</td>
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<tr>
<td>(neutral positivity)</td>
<td>(neutral positivity)</td>
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<tr>
<td>(negative positivity)</td>
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</tbody>
</table>

Figure 1 allows distinctions to be made between a form of "being positive" such as "symbiosis" in which there is indeed mutual enhancement. This contrasts with one such as "predation" in which one party (the controlling one) in a transaction prides itself on achieving a "positive" outcome at the expense of the other -- namely "feeding off" the other. This is distinct from the situation of "parasitism" where it is the latter party (the subordinated one) which successfully feeds off the former. The point about such a table is its merit in avoiding confusion between different forms of "being positive", some of which may be quite problematic because their "negative" aspects are camouflaged by appearing to borrow some of the desirable qualities of the mutuality of "symbiosis". Parasitism and predation are not relationships of mutually beneficial mutuality. One party effectively benefits at the expense of the other.

Haskell introduced the neologisms indicated in the above figure:

- allotrophy (derived from the Greek for "feeding the other"), namely one in which the activity of the system's work is not affected while that of the controller is unaffected
- alopathy (derived from the Greek for "making the other sick"), namely in which the activity of the system's work component is unaffected, but that of its controller is decreased

Similarly what might be considered most problematic is a form of (double) "negativity", typical of "synnecrosis" in the table, in which both parties lose energy through the interaction to the point of mutual destruction. But again this should not be confused with other hybrid conditions in which one or other may benefit unequally from the interaction. The table is an indication of the possible range of interactions between positive and negative as a form of psycho-social cybernetic system.

The table is particularly significant in that, as with environmental systems, it is not the case that all "parasitism" or "predation" should be eliminated from the pattern of psycho-social interactions -- however much there is an expectation that the "Lion will lie down with the Lamb" in a form of symbiosis. There are in fact conditions under which even synnecrosis would appear to be appropriate -- as in decay processes necessary as precursors to regeneration. The real challenge is to ensure an appropriate systemic balance between the various forms of interaction - and, metaphorically, to avoid "throwing the baby out with the bathwater".

**Ordering classes of interpersonal relationship**

Edward Haskell's insights have been very usefully (and extensively) adapted by Timothy Wilken (The Relationship Continuum, 2002) to an ordering of the spectrum of personal relationships: adversity -- neutrality -- synergy. Wilken equates "synergy" with "positive" and "adversity" with "negative" therefore pointing to the relevance of his adaptation to the preoccupation of this paper. Wilken's study reframes Haskell's above ordering in the following table, where "win" equates with "positive" and "lose" with "negative".

**Figure 2: 8-fold Pattern of Non-Neutral Relationships**

This raises the question whether a psycho-social system, any more than a biological one, can be based on expectation of a win-win outcome for all parties under all circumstances. How would life survive on the planet if there were not both "winners" and "losers" in the feed chain.
The emphasis on "win-win" is an exemplification of the focus on the positive (cf Hazel Henderson. *Building a Win-Win World: life beyond global economic warfare*, 1996). There are all sorts of reasons why this is a useful notion, and why there is useful mileage in it. The Judgement Day of religions might even best be understood as the day when every profoundly held belief system gets to say "I told you so" -- the only twist being that we cannot understand how each needs to understand how they were wrong in order to accommodate the rightness of others. It is at this level (which in biblical terms "passeth all understanding") that win-win does indeed hold in reality. It also holds as a useful slogan. But it is not clear that it is with this notion that we can build a sustainable bridge between the ideal and the practical levels for the following reasons:

- Ecosystems: Everybody is somebody else's lunch. It would be nice to assume that we could design a sustainable social ecosystem where this does not hold. We have not yet been able to demonstrate this.
- Learning: Kenneth Boulding (Ecodynamics: A New Theory of Societal Evolution, 1978) has a statement to the effect that we only learn through losing. From this perspective a win-win society is a strictly non-learning society.
- Sacrifice: Careful review of social change shows that real change only occurs through human sacrifice. Indeed it could be shown that most legislation is passed only after people have died as a consequence of its absence. The careers of most social innovators are marked by personal sacrifice. It can of course be argued that they "win" in other ways.

The point is that there are several understandings of "winning". People respond readily to the "gain without pain" interpretation. There is a danger that Henderson's book will be used as justification for this perspective. Although there may indeed be value in this, such appreciation will tend however to obscure other levels of interpretation which may well be where the real breakthroughs lie.

**Corresponding Taoist perspective: Ba Gua diagram**

There is a striking similarity between Haskell's cybernetically-inspired presentation and a widely-known classical Taoist presentation of the 8 basic trigrams of the I Ching -- ordered into what is termed the Ba Gua (or Pa Kua) diagram. This diagram of 8 "houses", also known as the Ba Gua Mirror, is the basic tool for Feng Shui analysis, providing a practitioner with keys concepts with which to analyze a situation [more | more]. There are a very large number of (often highly ornate) circular representations of the diagram available as images over the web. The following is a purely schematic tabular version of that binary coding system. The full and broken lines signify positive and negative respectively, each trigram (in the cells of the table) therefore constituting the codification of a particular positive-negative (win-lose) hybrid.

![Figure 3: Schematic representation of 8-fold Ba Gua (Pa Kua) Mirror](image)

Of greater relevance to the relationship between positive and negative (as fundamental to Taoist insight) is the use of this Pa Kua framework as one of the Chinese internal personal development systems intrinsic to qi gong breathing exercises, meditation and a particular martial art: Pa Kua.

The martial art variant of Pa Kua is known for its evasive footwork, including the characteristic circle walking and the spiraling, coiling, drilling, twisting, and spinning movements, combined with powerful palm heel strikes. Pa Kua is as much a martial arts combat style as it is a martial art taught for its health benefits. There is every possibility that the dynamic relationship between expressions of "positive" and "negative" in an interpersonal transaction can be usefully understood as a martial art. Metaphorically, "evasive footwork" is not something that is totally foreign to dialogue situations! The suggestion above that "being positive" might be understood as one form of form of game, from a transactional analysis perspective, can now be reviewed from a Chinese perspective where it is both game and martial art.

It may well be that the discipline of Pa Kua facilitates the emergence of skills in dialogue, or in responding to all complex combinations of positive and negative, winning and losing.

In the Pa-Kua approach to Feng Shui, the compass is divided into eight directions, each of which is depicted by a trigram (as above). Each of these directions has a different significance, depending on the individual. Four of those directions have a "positive" implication for the person, while the other four have "negative" implications. The eight directions can be briefly summarized as follows:

- Sheng Chi (Life Generating): Prosperity and wealth direction.
- Tien Yi (Heavenly Doctor): Health direction.
- Nien Yin (Relationships): Relationships direction.
- Fu Wei (Stability): Stability, tranquility and knowledge direction.
- Ho Hai (Mishaps): Accident or misfortune direction, relating to unforeseen accidents and losses.
- Wu Gwei (Five Ghosts): Financial losses and theft direction.
- Liu Sha (Six Killings): Direction relevant in warding off malevolence.
There is a vast body of Chinese literature exploring the philosophical and practical implications of this and related schemas -- and their extension to reflect finer distinctions in the pattern of psycho-social change through 64 hexagrams (Transformation Metaphors derived experimentally from the Chinese Book of Changes (I Ching) for sustainable dialogue, vision, conferencing, policy, network, community and lifestyle, 1997). Its merit is that it reframes the simplistic polarization of "positive" vs "negative", extending it to include a complex set of hybrid variants that are inadequately recognized by injunctions to "be positive" or "avoid negativity" (cf Discovering Richer Patterns of Comprehension to Reframe Polarization, 1998).

Given the theme of this paper, and the rich Taoist perspective, there is a certain irony to the widely cited point that the Chinese symbol for "crisis" is a compound of "danger" and "opportunity" -- "negative" and "positive". This can readily be used to exploit a crisis inappropriately (cf Victor H. Mair. How a misunderstanding about Chinese characters has led many astray, 2005). Perhaps the most dramatic example of such exploitation was the UK government communications specialist who advocated releasing controversial government policies on the occasion of the 9/11 crisis -- creatively taking the opportunity to ensure that the public would be otherwise distracted.

Transcending dualism

Implicitly recognizing the function of different systemic conditions identified in such tabular presentations, Bob Rusbasan (In Praise of Negativity, 26 September 1999) argues:

Negativity is not always bad. We have to make decisions about all kinds of things as we go through life, and that always involves balancing good and bad factors. Say you are a young parent, deciding where to send your fifteen-year-old daughter to school. You are considering two schools and have compiled a list of positive aspects of each. The schools are running dead-even, and you can't make up your decision. Then someone informs you that one of the two schools has a big rape problem. Would you ask which one? Or would you stand firm on your principle that negativity should not be a factor in your decision?

In envisaging ways of transcending positive-negative duality, it is worth noting that negativity tends also to be associated with "dualism" and adversarial "polarization", whereas it is then argued that "non-duality" is associated with being positive.

Many disciplines of spiritual experience (whether Eastern or Western) distinguish between:

- **Via affirmativa**: The way of affirmation is an approach to God through positive assertion about God's attributes. Many theologians claim that the *via affirmativa* is inadequate without the *via negativa*, because it, can speak only of the attributes of God, never of God's eternal nature.

- **Via negativa**: This approach to God through negation, "the negative way" or the "apophatic way", is a commonplace of all mysticism, based on the insight that no predicates attach to God; no words of description may be appropriately used. Stripping away any such delusions about God is understood as a preparation for the truth -- eliminating all that is not God creates the possibility of penetrating to the heart of the mystery. In Sanskrit the sense of "not this, not that" is expressed by the phrase *Neti Neti.*

From the Eastern educational perspective of the Ananda Marga Gurukul Network, Ac Shambhushivananda Avt (Cardinal Human Values, 2002) argues that core values are primarily of two types: *avidya*-related (those which lead to knowledge of divinity), *avidya*-related (those which keep people tied to a material perspective, ignorant of divinity):

Our life is a constant effort to maintain a dynamic equilibrium between the forces of *vidya* and *avidya*. Neither can we negate the *avidya* which is the basis of our physical existence nor can we undermine the *vidya* which propels and inspires us towards the divine stratum. Hence, we need a new paradigm of values which lead us towards a healthy balance between *vidya* and *avidya*, between centripetal and centrifugal forces, between introvertial and extrovertial movement.

It might be usefully asked whether both a *via affirmativa* and a *via negativa* are necessary to comprehension and response to any complex and challenging relationship -- not just to that of "God". What indeed is the "healthy balance" between the countervailing forces basic to any form of sustainability?

The poet John Keats (Negative Capability, 21 December 1817) is renowned for recognition of the essence of maturity in terms of "negative capability". This is the capacity of "being in uncertainties, mysteries, doubts, without any irritable reaching after fact and reason".

Dynamics of a sustainable cycle

If it is indeed the case, as demonstrated by Haskell in the case of ecosystems of animal species, that sustainability is achieved by an appropriate mix of of positive-negative (win-lose) conditions, the question is how this mix "works" -- and why the most appropriate system is not entirely based on a "win-win" condition. One insight is that the win-win condition is merely one particular dynamic, a game, that is sustained within a set of games that are mutually dependent for the viability of the system as a whole.

Elsewhere (Comprehension of Appropriateness, 1986) it was suggested that the interdependence of these "game" dynamics was expressed through a cycle linking them together. Understanding how such cycles of contrasting phases accomplish effective
transformational work in society may be facilitated by a thermodynamic metaphor. The Carnot reversible cycle of heat and work, basic to the operation of any heat engine. A **heat engine** is a thermodynamic system that can undergo a sequence of transformations which ultimately return it to its original state. The **Carnot cycle** involves four successive and contrasting operations:

- **expansion of a gas at a constant "hot" temperature:** the gas causes the piston to do work on the surroundings, driven by absorption of heat from the high temperature source.
- **expansion without change in amount of heat:** as a result of adequate insulation, the gas continues to expand, doing work on its surroundings, but associated with a cooling of the gas to the "cold" temperature.
- **compression at a constant "cold" temperature:** with the environment doing work on the gas, causing heat to be removed from the gas into the low temperature source.
- **compression without change in amount of heat:** as a result of adequate insulation, the environment works on the gas to compress it and causing the temperature to rise to the "hot" temperature.

The notion of a work cycle is introduced here because it is relatively clear that a living system cannot exist in a condition of stasis. Living is synonymous with one or more active work cycles through which energy is moved through feedback loops to ensure integrity in the moment. The most obvious in mammals may be the respiratory cycle. This energy may take the form of attention -- even vigilance.

The heat engine is driven by a particular difference between two conditions -- to produce mechanical work by carrying a working substance through a cyclic process. In the conventional heat engine this difference is temperature. Heat is transferred to the sink from the source, and in this process some of the heat is converted into work.

The suggestion here is that from a **general systems** perspective this may be generalized to apply to other forms of difference and other forms of work -- making it potentially relevant to new insights into socio-economic cycles necessary for sustainability (notably in the light of theory regarding the maximum efficiency of a Carnot cycle engine). The perceived difference between "positive" and "negative" may also drive such a cycle, possibly at an axiological level.

**Psycho-social heat cycles**

A variety of heat engines have been constructed. The question to be asked is whether an analogous variety of "heat engines" could be usefully recognized in psycho-social systems. For example, might the variety of such cycles correspond to the variety of metaphorical uses of "heat" currently recognized:

- political heat ("diplomatic heat")
- heated market ("heated competition", "heated rivalry")
- dialogue heat ("heated dialogue", "heated debate", "heated argument", "heated communication")

Of relevance to such explorations would be Marshall McLuhan (Understanding Media, 1964), given the distinction he explored between "hot" and "cool" media (cf Gordon Gow. Thawing out Media: Hot and Cool, 1995; G E Stearn, McLuhan: Hot and Cool, 1967). A hot medium is one that extends one single sense in high definition. Hot media are, therefore, low in participation, and cool media are high in participation -- requiring completion by the audience.

Also of relevance is the work of Orrin Klapp (Opening and closing: Strategies of information adaptation in society, 1978).

The concept of a work cycle is basic to thermodynamics -- and is exemplified by the Carnot cycle. Elsewhere (Composing and Engendering the Future, 2001), it was used to explore whether this provides insights into a necessary dynamic relationship between past, present and future in terms of the nature and focus of attention. This would be the challenge in a cyclic shift between various positive-negative combinations. Is there a sense in which living embodies some such cycle -- of which the the heat engine is merely a limited material analogue? The heat engine cycle does indeed have to relate past, present and future in order to sustain its activity.

The insights of such circulation may also be evident in the psycho-social attraction of certain pattern dances -- presumably providing some kind of time-binding resonance transcending past, present and future for participants.

**Disrupting the cycle**

Any attempt to isolate and prolong unduly the most effective work phase simply jeopardizes the ability of the engine to continue operating -- as is illustrated by the value of fallow phases in crop rotation. This may also be true of the "win-win" condition. It is then quite inappropriate to view the non-work phases as "inefficient". The operation of a task force (or meeting) of individuals with distinct functions may also be interpreted as involving a cycle of phases in which each function enters and leaves the limelight in turn. This is best illustrated by the results of research by R Meredith Belbin into the roles required for good teamwork. These have been labelled as: chairman, company worker, completer-finisher, monitor-evaluator, plant, resource investigator, shaper and team worker. A precondition of any one role type, especially the "most productive", jeopardizes both the appropriateness of the group's work and its ability to renew itself and continue functioning.

The different levels of attention required in discussing the relationship of distinct policies to policy cycles may be illustrated by the metaphors of walking and dancing. In walking the right and left foot are moved forward alternately, shifting the weight of the body from one to the other. Although in places of difficulty attention may be focussed on one foot to the exclusion of the other, the body can be more satisfactorily moved forward by focussing on the process of walking, namely on the alternation between the two contrasting positions. In a 2-party political process however, there is a necessary struggle between the "right" and the "left", with no institutionalized awareness of what is achieved by the process of alternation between them. There is little recognition of when it is appropriate to relinquish a policy (increasingly framed as "negative") in favour of an alternative (increasingly framed as "positive") and then renew it to fulfill a new role. This may perhaps be more accurately compared to the preoccupation of a drunkard, or a spastic, with the forward
movement of one leg (temporarily forgetting the need for the other).

Appropriateness of the 1st order may be compared to movement of a foot, whereas 2nd order appropriateness may be compared to the process of walking. Higher orders of appropriateness may be compared to dancing and to a cycle of dances. It is the movement between the steps, and the manner in which they are ordered, which renders the dance meaningful. Focusing attention exclusively on any individual step prevents the rhythm from emerging and thus obscures the meaning of the dance. It is the rhythm which guides the self-organization of a dance, based on the execution of the individual steps, whose importance can in no way be neglected. The test of the appropriateness of any new mode is whether it embodies a more "seductive" pattern in the sense of Jacques Attali (Noise: The Political Economy of Music, 1985). In terms of 2nd order appropriateness current policy initiatives -- and narrowly focused exhortations to "be positive" -- may be compared to a drunkard's walk, a monotonous dance or, more dangerously, a lock-step march.

The past century has provided widespread familiarity with engines, notably combustion engines in motorbikes and other vehicles. The operation of the piston cycle has entered collective consciousness in many ways -- as well as the distinction between 2-stroke engines, 4-stroke engines, irrespective of the number of cylinders. This suggests a line of inquiry as to whether thinking itself can be understood as operating in cycles that might be usefully modelled by such engines for many people. In this sense a basic cycle would alternate between the extremes of any form of polarized thinking -- with each extreme providing a turning point. One might be associated with the charge that drives the cycle. Clearly this might be understood as a cruder pattern than that associated with multiple cylinders -- if their operation could be integrated to reinforce a common rotation. Of special interest in this respect are rotary engines (cf the Wankel rotary engine).

Related to such understanding of an engine is that of gearing whereby rapid rotation is translated into slower and more powerful rotation that can perform certain kinds of work. Many forms of thinking might be associated with rapid cycles. These need to be geared down to speeds that can mesh with operations in the material world (see Conceptual Birdcages and Functional Basket-weaving, 1980). This challenge might be seen in relation to that of gearing down principle to practice.

Coaction cardioid: interrelating the "games"

As noted earlier with regard to Figure 1, Haskell's particular synthesis also highlighted the interrelationship of the different conditions through a cycle -- described as a coaction cardioid. This work has been extensively elaborated by Timothy Wilken (UnCommon Science, 2002).

In terms of Haskell's generalization of the periodical table of chemical elements, the cycle is the generally heart-shaped path of the radius vector in his Periodic Coordinate System. This system provides a symbolic representation of the nine possibilities whenever "parts" relate with other "parts" to form "wholes" or unities, and whenever choices are made by the "parts" within the "whole" or unity. As admirably explained by Wilken (UnCommon Science, 2002, pp. 141-145):

"It is important to be mindful that the minus signs represent loss (of order) and not negative integers. The plus signs represent gain (of order) and not positive integers. And, the zeroes represent states of no change (of order), rather than an integer with no content. Or, in the language of games: Lose, Win, or Draw.... Now if we are to depict what occurs as a result of the relationship between X and Y, we need an initial reference device.

The initial conditions of X and Y can in each case also be represented by the area of circles.

Then if we geometrically sum our circles, we get the "Initial co-Action Circle" whose area represents the initial state of the "union" X and Y as a "single" system.... It was considered a stroke of genius on Haskell's part to use this Initial Co-Action Circle as the fourth axis of the Periodic Coordinate System. This circle represents the state of the union at the beginning of a relationship. It is the geometric sum of (X) and (Y) at the initiation of their co-Action. This reference circle is made by sweeping a neutral Co-Action vector, ro, around the ORIGIN.

How do you represent whether or not a relationship or co-Action has a synergic or net (+) positive effect (increase in order), an adversity or net (-) negative effect (decrease in order), or a neutral (0) or no effect at all (no change in order). You must have a reference, what was the state of the system before the co-Action is initiated -- the condition of the individuals before their relationship begins. This is the role of the third axis -- the (0, 0) circle. Haskell sometimes called this the "scalar zero circle", sometimes the Circle of Atropy. Perhaps an even better name might be the Circle of Neutrality. This circle represents a net neutral relationship between (X) and (Y). But, regardless what we call it, the area of this zero-zero circle represents the geometric sum of X and Y's conditions at the start of the relationship. This represents the simple sum of their individual order before their interaction.

The cardioid cycle is then defined in relation (as seen in the figure below) to a circle of unchanging order (or entropy). The coaction cardioid turns into the zero-zero or scalar zero circle in the region of predominantly negative coactions (inturning, in Greek, is entropy) -- toward Alpha (in Teilhard de Chardin's terms). It turns out of the circle in the region of predominantly positive coactions (turning out, in Greek, is ectropy) -- toward Omega (again in Teilhard de Chardin's terms). The interactions, or "games", which reduce the degree of order (increasing entropy) are then within the circle, whereas those that increase the degree of order (decreasing entropy) lie outside the circle. The cardioid describes the "path" between these different conditions that is effectively associated with the sustainability of the system.
With respect to this geometric representation of Haskell's earlier tabular version (Figure 1), Harold Cassidy notes:

As an example, in labor-management relations there is a profit-sharing arrangement known as the Scanlon Plan. An essential feature of the Plan is to have a reference period before it is put into operation, so that one will know whether there is actually a profit or loss under the Plan and how much it is. The value or range of a variable, measured at this time, would serve to place the (O, O) circle in the upper right half of the manifold, and of net (-) within the reference (O, O) in the lower left. This yields a "Coaction Cardioid". Along the Axis of Atropy bisecting quadrants 2 and 4, the magnitudes of x and y are equal, but the signs are opposite, so the net coaction is zero. To the right and above this axis is what the philosopher Braithwaite calls the "cooperator’s surplus". Once more we complete the philosophical categories by calling attention to the "conflictor's deficit", as we name it, in the lower left, net (-) part of the manifold.

Mathematical functions of the cardioid

As noted by Wilken (UnCommon Science, 2002, pp. 159):

Haskell's Periodic Coordinate System presents syntropic, atropic, and entropic process on a single model. Synergic co-Actions represent sytropic process. Neutral co-Actions represent atropic process, and Adversary co-Actions represent entropic process. To accomplish this Haskell synthesized three geometries -- elliptic, plane and hyperbolic. He used Riemannian geometry to plot synergic co-Actions, Euclidean geometry to plot neutral co-Actions, and Lobachevskian geometry to plot adversary co-Actions.

Mathematically, as a curve, the cardioid has properties that distinguish it in terms of membership of an exceptional variety of remarkable curves:

- as special case of the epicycloid for which the rolling circle and the rolled circle have the same radius.
- as degenerate case of the limacon of Pascal, its orthoptic is the limaçon (see cardioid graphics gallery).
- evolute is equal to itself (another cardioid).
- as conchoid of a circle,
- as pericycloid,
- as pedal of a circle with respect to a fixed point on the circle,
- as (polar) inverse of a parabola,
- as cissoidal of two tangential circles,
- as catacaustic formed by rays originating at a point on the circumference of a circle and reflected by the circle,
- its catacaustic (with the cusp as source) is the nephroid
- as catacaustic, as well as a pedal, of the cissoid of Diocles
- its pedal is Cayley's sextic
- sinusoidal spiral

With respect to its generation:

- it is the envelope of the chords of a circle, between points P and Q, which follow the circle in the same direction, where one point has the double speed of the other. This construction is called the generation of Cremona.
- given a circle C through the origin, the cardioid is the envelope of the circles with as diameter the line through the origin and a point on C.

(see also cardioid enveloped by circles, cardioid as envelope of tangents, cardioid sliding inside nephroid, cardioid-evolute and involute)

It notably figures at the centre of a Mandelbrot set.
its own cardioid body [more | more]. The role of the cardioid in the Mandelbrot set is explored separately (Sustainability through the Dynamics of Strategic Dilemmas: in the light of the coherence and visual form of the Mandelbrot set, 2005). The relation of the Haskell coaction cardioid with that of the Mandelbrot set is being explored by Kent Palmer.

**Sustainability: interrelating the Carnot cycle with the Cardioid "cycle"**

Given the perspective of this paper, and notably from a general systems perspective, it is possible that the Carnot cycle and the Cardioid cycle can be related. It is also possible that any such generic cycle relating "positive" and "negative" conditions can also be related to the features of Ba Gua mirror, and notably as a reflection of the cycle of processes described in Taoist spiritual disciplines (discussed below).

It is possible that the 4-phase Carnot cycle and the 8-fold coaction cardioid can be interrelated, especially since their ideal representations do not necessarily correspond to their distortions in practice. The purpose in doing so is to provide metaphorical cues to what is understood about the positive and negative phases of relationships -- and to build understanding of the nature of the sustaining cycle.

![Figure 5: Carnot cycle (a), (b), (c), (d) -- Coaction cardioid cycle 1-8](image)

![Figure 6: Overlay of 4-phase Carnot on 8-fold Cardioid cycle (exploratory)](image)

<table>
<thead>
<tr>
<th>4-phase</th>
<th>8-phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>volume</td>
<td>temperature</td>
</tr>
<tr>
<td>expansion (isothermal)</td>
<td>constant, hot</td>
</tr>
<tr>
<td>expansion (adiabatic)</td>
<td>cooling</td>
</tr>
<tr>
<td>compression (isothermal)</td>
<td>constant, cold</td>
</tr>
<tr>
<td>compression (adiabatic)</td>
<td>rising</td>
</tr>
</tbody>
</table>

So, for example, is it the case that the qualities of a relationship are indeed associated metaphorically in a significant manner with the juxtaposed terms from the table above:

- **symbiosis / synergy**: expansive, constantly "hot" ("warm"), sustained by environmental reinforcement, with action on the environment?
- **synnecrosis**: compression (mutually destructive), constant, "cold", depletion (draining) back to environment, impact of environment?
- **commensalism / parasitism / allopathy**: expansive, sustained warmth but cooling, with action on the environment?
- **amensalism / predation / allotrophy**: compressive ("constraining"), rising temperature, with action by the environment?

**Correspondence with inner and spiritual cycles**

Potentially relevant insights into the above cycle may also be derived from the many spiritually-oriented disciplines of breathing (from the misleadingly superficial to the incomprehensibly profound) which necessarily focus on the respiratory cycle understood as divided into various stages of transformation of energy.

C G Jung, for example, associated these with a process of internal alchemy [more]. He proposed a meditative individuation process using the metaphors of alchemy and the archetypes of the subconscious -- anima, animus, shadow and projection, plus many others. Curiously it is Gregory Bateson in a section on Form, Substance and Difference [more] of his book Steps to an Ecology of Mind (1972) that relates the depth psychology work of Jung to the thermodynamics of Sadi Carnot. But it is in another book, translated by Jung's colleague
Richard Wilhelm (1929), that Jung comments on a fundamental cycle identified in a Chinese text *T'ai I Chin Hua Tsung Chih (The Secret of the Golden Flower)* -- more recently translated by Thomas Cleary (1991) -- which showed Jung how to initiate this alchemy through the breathing cycle [more | more | more]. This focus has also been compared to the Nestorian Gospel of St Thomas [more].

The much-cited Chinese work discusses the "circulation of the light" of awareness through various conditions during meditation [diagram] reminiscent (if only in the metaphors used to describe them) of stages of the Carnot heat cycle discussed above. The Taoist practitioners of "internal alchemy" (nei-tan) refer to a continual circulation of the ch'i (vitality principle) up the primary yang (positive), back or Governor Channel (tu mai or du mo) and down the primary yin (negative), front or Functional Channel (jen mai or ren mo) of the body. (see Lu K'uan Yü, Taoist Yoga, Alchemy and Immortality, 1970) [more].

The "circulation of the light" refers to the movement of energy along a central pathway -- posing challenges metaphorically reminiscent of the design and operation of high-energy particle accelerators, cyclotrons and synchrotrons (for which there are many applet demos on the web) [resources]. The "light" is associated with contemplation suggesting that a form of energy (awakened as the body becomes still) attains the qualities of the light as the mind focuses upon or contemplates the spiritual ideal [more]. It is implied that this cycle necessarily embodies the insights associated with the transformations of awareness encoded by the circular arrangement of the *I Ching* (or the simpler Pa Kua arrangement of t'igrams). Whilst breathing has traditionally been valued as a metaphor in terms of "inspiration", much remains to be discovered about how "inspiration" works for a group and how "expiration" is to be understood as its cyclic complement.

Clearly the vast Asian literature on "heat" with regard to the health of the body might usefully be reviewed in relation to the Carnot cycle. The inner alchemy of Taoism uses the metaphor of wai-tan or "outer cinnabar" which it superseded. Outer alchemy sought to achieve physical immortality -- perhaps to be usefully compared with the social project for "sustain ability" -- through means of an elixir produced by alchemical means. The combination of meditative breathing and sexual techniques of nei-tan echo the reduction and recycling process through the process of circulation of essence through the body, strengthening and replenishing of ch'i (vital energy) and resulting in the formation of the sacred and immortal embryo or soul. Beyond these processes is the belief that, under the normal conditions, natural processes result in a life cycle of seven states:

1. the generative state of the womb;
2. the state of birth and infancy;
3. the state of childhood;
4. the recognition of dichotomies following the division of yin and yang;
5. the separation of the five elements, imbalancing one another and encrusting the senses;
6. the predominance of acquired conditioning, governing emotions and desires; and finally,
7. the complete domination of mundanity, with the extinction of positive energy, leading to death

This natural cycle is reversed by the alchemical firing process in seven corresponding stages through which immortality is achieved. The stages are:

1. refining the self;
2. recognition of the true mind;
3. restoration of celestial awareness;
4. assembling the five elements;
5. merging yin and yang - formation of the golden elixir;
6. unification of energy - formation of the spiritual embryo;
7. transcending the world - incubation of the spiritual embryo.

Through this process reality is cultivated, restoring the self, which otherwise gradually dies through the natural (entropic) process described above. Real celestial positivity returns in the midst of total mundanity. Inner alchemy may thus be described in terms of processes whereby real knowledge (symbolized by water) is retrieved from the overlay of artificial conditioning. The real knowledge is then used to replace the mundanity infecting conscious knowledge (symbolized by fire), thereby restoring the basic completeness of the primordial celestial mind.

Expressed differently, the challenge of human development is that consciousness is normally volatile, given to imagination and wandering thought. Real knowledge then tends to become submerged in the unconsciousness, sinking into oblivion. There is no appropriate integration of the two forms of knowledge which act separately from one another. Through the alchemical process, these two forms of knowledge are forced to interact. Real knowledge (water) stabilizes consciousness (fire) and removes its volatility, while consciousness brings real knowledge into action in life. The task of alchemy is therefore twofold, to "empty the mind" and to "fill the belly". The first is that of cultivating essence - ch'ing - displacing the mundane preoccupations of the human mind. The second is that of cultivating life or vital energy - ch'i. When the "belly is full", sane energy arises through accumulation of right action, and the energy of mundane conditioning dissolves of itself.

An alternative representation of the task is that of discovering the flexibility within strength and the strength within flexibility. Another is that of seeking sense through essence and returning essence to sense, meaning that essence and sense unite. The "firing process" is a metaphor employed in alchemical texts for the order of practical spiritual work, namely the order of application of effort in the cultivation of reality. The aim is to purify the vital energies, which are said to have their physical aspect within the body, so as to unite with the immaterial aspect active in the universe. Associated with this process is the notion of a "crucible" which is subjected to the firing and within which transmutation takes place, the human body in which ching and ch'i are melted together to form *shen-t'ai*, a new being, the sacred embryo or soul.

This is the famous golden flower which opens when enlightenment is attained, the transmutation as when the soul leaves the dying body.
and ascends to immortality in heaven. It is through the firing process that the encrustations of the faculties are burnt away to expose the awareness of the original spirit - shen. This requires an appropriate combination over time of inward discipline, deflection of externals, application of effort, gentle nurturing, and use and withdrawal of energy. Originally the disciplines were mainly based on meditative techniques involving control of breath as a means of developing shen-t'ai through purification of ching to form chi and then of chi to form shen. Finally the self is integrated with the universe as the mind is purified and returns to nothingness.

The philosophical approach - tao-chia - thus described derives from a more religious approach - tao-chiao. Through normal life the store of chi is gradually exhausted. The aim of inner alchemy - nei-tan - is to balance yin and yang so as to become one with the Tao; and to conserve and strengthen the inner essence - nei chi - through the inner alchemical firing process so as to restore the pure state of the essence as it was at the moment of birth when the primordial energy from which the universe arose entered the body. It is this primordial chi which forms the mind - shen, the body itself forming saliva - yu-chiang - and semen - ching.

Different meditative techniques have evolved with these ends in view, some clearly viewing the whole process as spiritual while others adopting more physical manifestations of the spiritual process to achieve the desired result, which may be reduced thereby to a desire for physical longevity ("sustainability").

(i) Fang-chung shu, symbolic or actual sexual techniques aimed mainly at exchange of energy through intercourse with a person of the opposite sex. Attention is on experiencing Tao through participation in the creative process reflecting the original creation of the universe. Or ching may be preserved by suppressing ejaculation while bringing one's partner to climax. Attention is on accumulating energy at particular "centres" through circulation of the primordial essence within the body.

(ii) Meditative techniques concentrating on the inner breath - ch'i - while taking in pure air and exhaling contaminated air without loss of ch'i, which is first harmonized - tiao ch'i. Other exercises may follow.

Meditative practices are employed in the process of creating channels for the essence to circulate. There are two channels, first the hsiaoou-chou-ten (lesser celestial circulation, small round), descending from the heart through the lower abdomen to the kidneys; and then the greater celestial circulation (great round), involving the whole body and passing through a number of "centres" from the base of the spine upwards - tu-mai (controlled path) - to the top of the head, then down - jen-mai (involuntary path) - through the face, chest and surface of the abdomen back to the base of the spine.

A particular concern of the practices of the Secret of the Golden Flower is "protection of the centre". This is effectively framed by the 8 outer conditions of the Ba Gua mirror and the 8 associated practices (or perhaps "games") of Pa Kua -- which may each be understood as having a different function in protecting the centre. The centre is present as the central "neutral" cell in the tabular representations above. Of it that text relates:

The center is omnipresent; everything is contained in it; it is connected with the release of the release of the whole process of creation. The condition is the portal. The condition, that is the fulfillment of this condition, makes the beginning, but it does not bring about the rest with inevitable necessity. The meaning of these two words is very fluid and subtle. [more]

Understanding a cardioid pattern of transactional relationships

The suggestion here is that, whilst a Carnot heat engine cycle and the Cardioid Coaction "cycle" can be fruitfully compared, the nature of the latter is of a higher order of complexity. This is especially the case with regard to its comprehension. It is for this reason that "parts" of it are more readily understood in isolation -- as "games", such as "being positive". These transactional games may indeed be linked as a cyclic process, but perhaps only at a higher order of dimensionality. The geometry of how the cardioid is generated merits further exploration as a focus for insight [more].

The cardioid may well function as a kind of value attractor (cf Human Values as Strange Attractors: Coevolution of classes of governance principles, 1993). In this sense it is perhaps more fruitful to look further at the way in which the different "games" as transactional patterns, define the contextual cardioid pattern -- namely the sense in which all the games need to be evoked in order for sustainability to hold.

| Figure 7: Transactional game patterns defining a coaction cardioid  
| (with traditional Taoist magic square numbering) |
Figure 7 endeavours to hold phrases typically used to describe particular game patterns in a mature interpersonal relationship. More specific variants could be elaborated for dialogue relationships, environment/socio-economy relationships, etc. Corresponding terms would be used to describe game patterns in an intergroup relationship. In that case, for example:

- patterns 7 and 9 would be descriptive of the kinds of relationship that hold between the UK and the USA
- patterns 4 and 6 would be descriptive of the capitalist ("predatory"), and the socialist ("parasitical") relationship respectively
- patterns 3 and 1 would be descriptive of dysfunctional characteristic of those between developed and developing countries, or between ethnic groups
- pattern 8 would be descriptive of "cycle of violence" relationships, as in the Middle East (possibly in conjunction with patterns 3 and 1)

As a symbolic structure, the cells are numbered according to the Pa Kua pattern of trigrams as a magic square in which all rows and diagonals sum to the same total, in this case 15 (cf 9-fold Higher Order Patterning of Tao Te Ching Insights: Possibilities in the mathematics of magic squares, cubes and hypercubes, 2003). The structure might well provide a framework for other insightful patterns (as a diamond and in relation to the Tree of Life).

The level of abstraction associated with the cardioid as an attractor is such that it raises the question of how the dynamics associated with that pattern are to be recognized as a whole rather than through the sub-pattern transactional games. It is perhaps Ron Atkin (Multidimensional Man; can man live in 3-dimensional space?, 1981) who has best explored how knowledge and communication spaces of this kind might be articulated on the invisible complex boundaries which can only be subliminally sensed by effectively "feeling the geometry" -- effectively sensing the local constraining curvature of the transactional space (cf Social organization determined by incommunicability of insights).

"Disorders of the heart"

It is tempting to explore the features of Figure 7 in terms of the "chambers" of a heart through which it sustains circulation of the "blood" in various forms of individual and collective relationships. This could be understood in the light of the earlier discussion of the Carnot cycle (Figure 5)...

Given the symbolism of the heart -- in personal relationships (Cupid, etc), spiritual relationships (Sacred Heart, etc), in caritative relationships, and in relation to socio-political economy ("heart of the group", "heart of the economy", "heart of the nation", etc) -- the "failure of the heart" is worth examination in the light of the above cardioid of transaction patterns.

- "Broken heart": is this understanding usefully associated with a dysfunctional focus on the net synergy (or even the consummatory aspects) of a relationship? Can the underlying cardioid pattern be understood as vulnerable in different ways -- to different modes of "breaking"?

- "Bleeding heart" / "Hard hearted": are these extremes indications of insights into other modes of dysfunctionality in a transactional relationship?

- Heart failure (and disorders): is the incidence and nature of such physical phenomena associated in any way with the variety of "disorders" of the cardioid as a generative or holding pattern of socio-economic sustainability?

- "Heart deformation": can the cardioid pattern as an attractor be usefully understood as "deformed" under certain circumstances?

With the USA as the cultural context in which "being positive" is emphasized to a high degree, is it possible that there is a significant correlation with the incidence of broken relationships and heart failure?

Dangerous consequences of ignoring the cycle

The management challenge with regard to "positive" may perhaps be more usefully compared to that of a gardener. Typically particular plants may need "more light" or "more shade", "wetter soil" or "drier soil". The variety of plants and conditions have to be appropriately interrelated in the concrete situation (notably as in the discipline of permaculture). Issues of management may therefore include,
The curiously fundamental role of the cardioid in the above exploration suggests symbolic possibilities

- when to encourage and appreciate an orchestra playing (on the sinking Titanic, when disaster was inevitable), and when it is a distraction from concrete action (Nero fiddling while Rome burns)
- when to encourage the ability of those with skills to identify and fix "dirty" problems (overflowing sewers, multiple gunshot wounds), and when to appreciate the "prissy" unwillingness to "muck in"
- when to acknowledge that there is a "problem" (as in the first step in Alcoholics Anonymous: "I am an alcoholic"), and when to focus on potential (irrespective of the problems)

The requisite perspective is then not to blindly favour "positive" over "negative" but to understand when to favour one rather than the other and how to sustain over time the cycle shifting between combinations of "positive" and "negative". The practicalities of how to do this with heat engines were basic to the miracle of the industrial revolution. The challenge of how to design operational "value engines" and "axiological pumps" remains.

Life-skills required for "self-management" call for analogous flexibility in acquiring the grace and elegance associated with maturity in:

- knowing when and how to lose, notably in order to develop...
- knowing when and how to win

The dilemma is somewhat analogous to the choice offered between:

- allopathic treatments using pharamaceutical products targetted to a specific illness (that may only be a symptom), namely without addressing the lifestyle issues that will tend to re-englender that problem
- homeopathic treatment using products in the light of a whole-system perspective that may not effectively address the immediate suffering

The dynamic between the various positive and negative combinations may perhaps be best understood through archetypal popular tales -- so-called learning stories -- or even TV soap opera. For example, consider the array of the 8 best-known characters around Christopher Robin (Winnie the Pooh Character Guide: Pooh, Piglet, Eeyore, Tigger, Rabbit, Owl, Kanga, and Roo (see also Benjamin Hoff. The Tao of Pooh; Anna Ludlow, Pooh's Little Book of Feng Shui, 2000) [more]. These characters might fruitfully be matched with the above-mentioned Pa Kua / Ba Kua directional classification (possibly having Pooh at the centre and Christopher Robin as a character). Such a correspondence has already been associated with the construction of the Beech Hill Stone Circle in the heart of Ashdown Forest (Pooh's traditional home ground).

The cycle may perhaps also be recognized in various classical tales based on the notion of a ring (cf The "Dark Riders" of Social Change a challenge for any Fellowship of the Ring, 2002). Possibly the most intriguing "ring" features in one of the principal classic tales of China -- that of the Journey to the West written by Wu Cheng'en in the 16th century (and translated by Arthur Waley, 1942). Otherwise known as The Monkey King, this is the tale of Monkey as the mischievous protagonist who takes on the heavens and the gods in a sequence of stories with a group of companions.

The subtle dynamic of give-and-take is basic to many Eastern martial arts. Increasingly these are translated into strategic management thinking (Chin-Ning Chu, The Asian Mind Game: unlocking the hidden agenda of the Asian business culture - a weste's survival manual, 1991; Scott Boorman, The Protracted Game: A Wei-ch'i Interpretation of Maoist Revolutionary Strategy, 1969) [more]

Symbolic possibilities

The curiously fundamental role of the cardioid in the above exploration suggests that further reflection would be useful on:

- the cultural role widely played by the "heart" in relation to true romance -- particularly with the implication that true romance is sustained through a cycle that involves not only the synergy of consummation (on which the prime focus is conventionall placed), but also through a range of more or less awkward, or even mutually destructive phases (described as characteristic of a "mature relationship")
- the role played by the heart in various religions from the Aztec to the Christian, and all that is associated with its "bleeding"
- the complex mathematical properties of the cardioid and what these may imply for the degree of complexity required to both understand and achieve socio-economic "sustainability"
- the common visual image of the heart as "pierced" (by Cupid's arrow) and the significance of that arrow in the coaction model and its cybernetic underpinnings
- as a special case of the epicycloid, the vertex of a cardioid is recognized as coinciding with a rose petal tip, as defined mathematically, thus linking any such set of cardioids to the extensive symbolism of the rose -- and raising the question of how the function of such a set is to be understood in relation to the sustainability of any relationships (and the place held by rose patterns of different complexity in distinguishing various chakras in yoga)

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