



laetus in praesens

Alternative view of segmented documents via Kairos

21st March 2006 | Draft

Conformality of 7 WH-questions to 7 Elementary Catastrophes an exploration of potential psychosocial implications

-- / --

Annex to *Council of the Whys: emergent wisdom through configuration of why-question dynamics*

Introduction

[Catastrophe theory](#)

[Applications of catastrophe theory](#)

[Cognitive feel for cognitive catastrophes: question conformality \(Annex\)](#)

[Correspondence of WH-questions to elementary catastrophes](#)

[Why-questions and the parabolic umbilic](#)

[Pointers to comprehension of multi-dimensionality of WH-questions:](#)

[Skateboarding](#) | [Sexual attraction and intercourse](#) | [Multiple intelligences](#) | [Psychosis / Neurosis](#) | ["Games people play"](#) | [Strategy games](#) | [Meditation](#) | [Symbolism](#)

[Psychosocial implications of WH-questions as "catastrophes": when, where, which, how](#)

[Psychosocial implications of WH-questions as "catastrophes": what, who, why](#)

[Interrelating Cognitive Catastrophes in a "Grail-chalice" Proto-model \(Annex\)](#)

[Conclusion](#)

[References](#)

Introduction

As a human response to the perception of a cognitively chaotic situation, WH-questions (when, where, which, how, what, who/whose, why/wherefore) might be considered to lend themselves to analysis with the tools of [catastrophe theory](#) as developed by [Rene Thom](#) and others. Thom had developed differential topology into a general theory of form and change of form as a mathematical way of addressing the work on [morphogenesis](#) done by C.H. Waddington in the 1950's. Thom's Classification Theorem culminates a long line of work in singularity theory. The term "catastrophe theory" was suggested by C. Zeeman (1977) to unify singularity theory, bifurcation theory and their applications. The crucial theorems rigorously establishing Thom's conjecture were proven by Bernard Malgrange (1966) and John N. Mather (1968). Its essential concern is change and discontinuity in systems (cf Robert Magnus, [Mathematical models and catastrophes](#)). WH-questions may be considered as triggered and formulated in response to discontinuity -- when habitual adaptive responses to change are inadequate.

It is possible therefore that the set of WH-questions may in some way be mapped onto elementary catastrophes. This is partially suggested by mathematical techniques of [conformal mapping](#) where, for example, the "cognitive flow field" around one known shape (as with an elementary catastrophe) might be mapped onto the flow field around a particular WH-question -- preserving the "angles". Conformal mapping notably makes use of complex variables as combinations of real and imaginary numbers. [[applet](#)]

Whilst the purpose here is to highlight the role of why-questions in the set of WH-questions in the light of catastrophe theory, there is a certain irony to the following description of Thom's own focus by Christer Persson ([Elementary catastrophe theory: an introduction](#)):

In science two main lines of questioning compete or co-operate; one asking "How?", the other asking "Why?". In biology Thom had an irritating tendency to counter each answer to a "Why?"-question with cascades of "How?"-questions, the intent being to demonstrate the inadequateness or provisional character of "guiding thought" in biology. When answered: "Because messenger-RNA duplicates information from the DNA spiral and turns to ribosomes, where proteins are synthesized...", he promptly asked:

When? How does it know when? How does it switch from one state to another? Following what roads? Where is the map?

Given Rene Thom's interest in semantics and linguistics, the discontinuity introduced into discourse by a question, and his predisposition to question the assumptions of others, it might be asked whether he endeavoured -- perhaps self-reflexively -- to relate elementary catastrophes to WH-questions in some way that is not evident in the published literature.

This exploration develops aspects of earlier work on WH-questions (*Functional Complementarity of Higher Order Questions: psychosocial sustainability modelled by coordinated movement*, 2004; *Engaging with Questions of Higher Order: cognitive vigilance required for higher degrees of twistedness*, 2004). The dysfunctionality associated with WH-questions is explored separately (*Question Avoidance, Evasion, Aversion and Phobia: why we are unable to escape from traps*, 2006).

Catastrophe theory

Catastrophe theory identifies *degenerate critical points* of the potential function -- points where not just the first derivative, but one or more higher derivatives of the potential function are also zero. Mathematically these are called the germs (singularities or organizing centres) of the catastrophe geometries [more]. Thom listed all these germs and their unfoldings for cases involving up to five parameters. He also proved that any family of potentials depending on up to five parameters is structurally stable and equivalent around any point to one of these canonical forms. Such equivalence and the properties of stability and typicality arise from Thom's transversality and isotropy theorems and from Mather's theorems on stable unfoldings [more].

When the degenerate points are not merely accidental, but are structurally stable, they exist as organizing centres for particular geometric structures of lower degeneracy [more]:

- For any system with four (or less) control factors and two (or less) behaviour axes there are only **seven elementary catastrophes** possible [more].
- Where the sum of the control and state dimensionalities equals **eleven** it is possible to classify eleven families of catastrophes to some degree.
- Beyond this level of dimensionality even the categories of families of catastrophes apparently become infinite and hence very difficult to classify. For dimensionalities greater than five in the control space and two in the state space the number of catastrophe forms is **infinite**.

In other words, given certain constraints, all discontinuous changes in events can be described by one of **seven elementary models**. When a system is therefore characterized, in spatial or temporal interpretations, by:

- Potential functions of one active (or "state", or "fast") variable (or behavioural axis) and
 - one input variable (control factor, or "slow variable"), catastrophes take the form of a **fold** [more | applet]
 - two inputs, catastrophes take the form of a **cuspid** [more | applet]
 - three inputs, catastrophes take the form of a **swallowtail** [more | applet]
 - four inputs, catastrophes take the form of a **butterfly** (containing a "pocket" of compromise-- with a surface in 4D) [more | applet]
- Potential functions of two active (or "state", or "fast") variables (or behavioural axes) and
 - three input variables (control factors, or "slow variables"), catastrophes take the form of either:
 - a **hyperbolic umbilic** [more | applet] or
 - a **elliptic umbilic** [more | applet]
 - four inputs, catastrophes take the form of a **parabolic umbilic** [more | applet]

The forms of the first four catastrophes have been clearly illustrated in spatial (but not temporal) terms by folding paper by Leong Chen Chit (*Origami and Catastrophe Theory*):

We can translate the first four manifolds of Catastrophe Theory into origami folds. The first one, the Fold manifold, is the equivalent, in flat origami, of the mountain/valley fold. It has no cusp point. The second catastrophe geometry, the Cusp manifold, is the equivalent, in flat folding, of the reverse fold; third, the Swallowtail manifold, is the equivalent of the double reverse fold; and fourth, the Butterfly manifold, the triangular sink fold.

Applications of catastrophe theory

After initial enthusiasm, Thom's approach has attracted criticism from mathematicians with quantitative and predictive priorities, notably concerned by "spurious quantization". However his considerable interest in linguistic, semantic and psychosocial issues in the development of his general theory continues to offer a qualitative approach that is appreciated in applications of catastrophe theory in the social sciences [more | more]. Widespread use of catastrophe theory has been made for such modelling (cf Brian R. Flay. *Catastrophe Theory in Social Psychology: some applications to attitudes and social behavior*, 1978; Wolfgang Wildgen, *Catastrophe theoretical models in semantics*, 2004). In *The Mathematics of Discontinuity*, a balanced and extensive review of the strengths and limitations of catastrophe theory in the light of such criticism, is provided by J. Barkley Rosser, Jr (*From Catastrophe to Chaos: a general theory of economic discontinuities*, 2000, Ch. 2). He concludes that early criticism, now recognized as partly inappropriate, resulted in the "baby being thrown out with the bathwater".

Such appreciation contrasts with that of the dismissive footnote of Philip A. Schrodt (*Patterns, Rules and Learning: computational models of international behavior*, 2004)

... chaos theory--despite its faddish character--has important implications for international relations modeling that catastrophe theory--the previous mathematical fad -- did not. The popular catastrophe theory models required systems that were homeostatic *and* minimized a quartic (cusp catastrophe) or hexadic (butterfly catastrophe) function *and* used continuous time *and* contained two or more independent, real-valued parameters. The "general" topological results of Rene Thom basically applied only to mathematical abstractions, and only rarely to empirically realizable systems. Chaos theory, in contrast, applies to models that have been in common use for decades and have realistic features such as quadratic feedback, discrete time, and interdependent parameters.

Schrodrt's position is consistent with advocates of complexity theory (as compared to both catastrophe theory and chaos theory). This recognizes that complex systems, considered in their totality, have more than one attractor acting simultaneously and interdependently. The emphasis of catastrophe on one form or another may therefore be considered a questionable form of reductionism. Individual attractors can certainly be studied, but any assumption of their independence is questionable, as strongly argued by Chris Lucas (*Questioning Our Methodologies*, 2006). For Lucas, WH-questions cannot in practice be treated in isolation however distinct the sentences in which they are embedded.

From the perspective of complexity theory, in response to earlier drafts of this paper, Lucas has proposed useful tabulations (as below) of the relations between the set of WH-questions (for both questions and answers) in terms of four methodological scopes.

WH-Question Methodologies (as developed by Chris Lucas, <i>Questioning Our Methodologies</i> , 2006)				
Question Type	Scientific Scope ("material")	Personal Scope ("living")	Humanistic Scope ("community")	Spiritual Scope ("holistic")
When do I ask questions ?	Once ?	Occasionally ?	Regularly ?	Constantly ?
Where do I ask questions ?	One Place ?	A Few Places ?	Many Places ?	Everywhere ?
Which systems are relevant to my questions ?	One only ?	A Few ?	Many ?	All of Them ?
How do I ask questions ?	In One Way ?	In Several Ways ?	In Many Ways ?	Every Way ?
What questions do I ask ?	Single Issue Ones ?	Limited Issues Ones ?	Multiple Issue Ones ?	All Issue Ones ?
Whom do I ask questions for ?	Myself ?	Social Group ?	Humanity ?	All Stakeholders ?
Why do I ask questions ?	For Control ?	For My Quality of Life ?	For Group Quality of Life ?	For Development ?
Attractor Type	Point	Cyclic	Strange	Transient
Valuation Type	Systemic	Extrinsic	Intrinsic	Holarchic
Logic Type	Boolean	Fuzzy	Matrix	Integral
Thought Mode	Reactive	Uniordinal	Multiordinal	Synergic

For Lucas:

In general axiological terms the first column, the scientific, is a systemic valuation mode -- it concentrates on dualistic right/wrong approaches using Aristotelian or Boolean logic. The second, personal, is an extrinsic valuation mode -- it concentrates on acquisition or maximisation and is a fuzzy logic approach, the third, humanistic, is an intrinsic valuation mode, it relates to the whole and to matrix logic. The fourth, spiritual, is my holarchic valuation mode, associated with integral logic.

It has been claimed that: "The politically-correct notion that 'What' and 'How' questions belong to science, and that 'Why' questions belong to religion, has been intellectually defunct for over a century" [more]. But, curiously, as exemplified in the anecdote concerning Thom (above), echoed by Lucas (2006) and others [more], why-questions indeed relate primarily to meaning, semantics, or values -- with science tending to reject or marginalize these as not being a valid theme of research. The nature and extent of such question avoidance is discussed elsewhere (*Question Avoidance, Evasion, Aversion and Phobia: why we are unable to escape from traps*, 2006).

Philosophy makes a similar distinction, as noted by Lee Archie, et al (*Reading for Philosophical Inquiry A Brief Introduction to Philosophical Thinking*):

Sometimes the distinction between science and philosophy is made by noting that philosophy attempts to answer the question 'Why?,' and science attempts to answer the question 'How?' Is there a difference in the kinds of answers which would satisfy each kind of question? Is the difference between why-questions and how-questions the same as the difference between arguments and explanations?

The issue of the relationship between "how" and "why", and their implications for governance, continue to be fundamental to the debate between religion and science [more]. The challenge is highlighted on a BBC "style and usage" page on *Why* (2002):

It has long been clear that why questions are not as easily answered as their how and what relatives. There is something in a why question that ensures that, while they may be answered correctly, such correctness is only in the mind of the perceiver.... What then is different about *why* questions? Well, *why* questions do not actually necessitate objectively true answers. An infinite number of answers may be posed for any *why* question, all of which may be true...

With such large emphasis on science in the modern world, it is no surprise that science is often heralded as the answer to all one's questions. Unfortunately, science has some major limitations in this area. There is a large set of questions that science is necessarily prevented from answering. And it is the set of *why* questions. There is a simple reason for science's inability to

answer *why* questions, and that is that science *assumes* causality as its most fundamental premise....

Why questions have a peculiar subtlety in their interpretation that is unique to them. This is because one can mean two different things by *why* and the difference between the two is often overlooked. It arises from a tacit agreement to one of two juxtaposed world views.

Thom however defended his use of qualitative methods, arguing that science constitutes a continuum between the poles of "acting effectively on reality" (with quantitative tools) and "understanding reality" (with qualitative approaches). The latter involved heuristic "classification of analogous situations" by means of "geometrization that promoted a global view while the inherent fragmentation of verbal conceptualization permits only a limited grasp" (cf Rene Thom, *Mathematical Models of Morphogenesis*, 1983).

Given the global condition at the beginning of the 21st century, it remains unclear whether "chaos theory" or "complexity theory" will have more to offer than "catastrophe theory" in the face of the increasing number of catastrophes in an increasingly chaotic society -- in what many see as a world that is increasingly complex and incomprehensible -- and ungovernable, other than through processes of fabricated threat and subterfuge (cf *Promoting a Singular Global Threat -- Terrorism: Strategy of choice for world governance*, 2002). It is regrettable that the mathematical disciplines, with so much to offer in reframing the situation, should be in thrall to such a degree to the defence and security agendas exacerbating this condition -- or dedicated to priorities in outer space more readily susceptible to mathematical solutions (cf *And When the Bombing Stops? Territorial conflict as a challenge to mathematicians*, 2000).

In a highly problematic world situation there is however merit in exploring the use of any approach -- however apparently outmoded -- that may facilitate new thinking and the capacity to act on it. Einstein noted that the thinking that had led humanity into its problems would not be the thinking that would lead it out of them. He asserted that moral questions -- namely including the why-questions -- were of utmost importance for human existence and that in order for humanity to continue, it must create a moral order. As argued by William L. Johnson *et al.* (*Science and Religion at a Crossroads: An Educational Perspective*, *Quodlibet Journal*, 1, 6, 1999), "Science must ask the 'why' questions as well as the 'how' questions. It cannot be divorced from issues that take humanity quite beyond science itself". [John Archibald Wheeler](#) evoked the possibility of a "meaning physics" in which the "why" and "how" questions were resolved together in understanding of the freedom and order of the development of the physics of the world (Wheeler and Zurek 1983).

The challenge for institutionalized "science" and "scientists" in a highly turbulent world is the risk of finding themselves perceived to be trapped into responding only to "when", "where", "which" and "how" questions -- as being the exemplification of "science". Their response to:

- **what-questions**, may then come to be characterized by the well-recognized problematic professional and institutional dynamics and resistances associated with "scientific revolutions" and **paradigm shifts**, including misinterpretation and suppression of evidence. For scientists the determination of "what field" or "what speciality" is a typical preliminary to valid communication -- determinations typically subject to disruption by scientific revolutions that redefine boundaries between specialities.
- **who-questions**, whilst claiming impersonal objectivity, may then be perceived as closely associated with the well-recognized, questionable, "unscientific", professional issues of territory, **groupthink**, science politics, mutual citation networks, creativity-inhibiting peer review systems, and overriding patterns of personal and institutional ambition (cf. Carl J. Sindermann. *Wining the Games Scientists Play*, 2001). Of particular interest is the predetermination of relevance on the basis of "who" is the source of information.
- **why-questions**, may only become evident in the consequences of "unscientific", unquestioning commitment to particular belief systems -- as is evident with respect to faith-based science, to ethical issues relating to the **social responsibility of science**, including complicity in development of destructive technologies. The capacity of conventional science to address why-questions is indeed a matter of continuing debate (as any web search on "*why questions*" science will make apparent).

The challenge might be framed as follows:

- **what** is being done inappropriately is well-documented and widely recognized (cf *Encyclopedia of World Problems and Human Potential*)
- **who** is doing it is a matter of continuing debate in the search for those to blame and those to emulate -- although one's own complicity may go unrecognized
- **why** "who" is doing "what" is a question that is avoided and framed as inappropriate -- especially with respect to one's own valued or habitual initiatives

There is however a danger that the rigour of complexity theory may take it beyond the point where it can be related to anything that can be grasped with respect to practical policy initiatives -- a conceptual equivalent to the application of the **Peter Principle**. It is one thing to recognize the principle that *'The first law of ecology is that everything is related to everything else'* (**Barry Commoner**). But it is quite another to devise appropriate, communicable strategies in response to a particular issue. The comprehensibility of an adequate explanation -- as an approximation in a world of compromise -- may be of greater value to sustainable social change than its diminished significance in a more fundamental framework. After all, even astrophysicists continue to use the geocentric phrase "the sun rises".

A generalization of catastrophe theory, avoiding controversial issues explored by the Thom-Zeeman approach, has been produced by [Vladimir I. Arnold](#) (*Catastrophe Theory*, 1998). For Arnold: "Singularities, bifurcations, catastrophes are different terms for describing the emergence of discrete structures from smooth, continuous ones." His mathematical generalization of **singularity theory** takes the focus off the limited set of "elementary catastrophes" that are particularly susceptible to visual representation (and real world examples) and stresses the much larger range of singularities. However, in what follows, the concern is specifically with discontinuities that are comprehensible and meaningful to the constrained human mind as a description of behaviour -- rather than with singularities that can only be represented mathematically. Of relevance to what follows, however, is the focus in singularity theory on the failure of **manifold**

structure -- which might be understood in non-mathematical terms as the the kind of breakdown of coherence and definition that evokes questions.

Cognitive feel for cognitive catastrophes: question conformality

This theme is developed in an [Annex](#) whose contents are:

- [Introduction](#)
- [Cognitive feel and conformality](#)
- [Conformality in philosophy](#)
- [Sense of a question](#)
- [Formalization of questions](#)
- [Subjective and cultural factors](#)
- [Representation of questions](#)
- [Postmodernism and cognitive discontinuity](#)

Correspondence of WH-questions to elementary catastrophes

As described by Thom, the seven "elementary catastrophes" are presented below (together with his "archetypal morphologies"). A possible cognitive correspondence to WH-questions or interrogatives has been tentatively added (*in italics*). Most languages have seven interrogatives. The literature variously recognizes seven or eight WH-questions. For example the BBC recognizes eight [more], whereas as "interrogatives" only 7 are recognized in scriptural studies (cf The Christian and Missionary Alliance, *Bible Quizzing Rule Book*, 2004: "The seven permissible interrogatives are who (or a form of it), what, why, where, when, which, and how."). Note the assumptions in the table that: the who-question is considered to include "whose" and whom"; the why-question to include "wherefore" (even though the latter emphasizes purpose, whereas the former emphasizes cause); and that any "whether" question can be reduced to a which-question.

WH-questions in relation to the "elementary catastrophes" of catastrophe theory (adapted from Rene Thom) with addition of tentative cognitive correspondence to WH-questions							
Singularities "catastrophes"	Organizing centres	Physical examples (substantives)	Dynamics	Archetypal morphologies		WH-questions	
				Destructive	Constructive	Question	Property
Fold	$V=x^3$	Edge, end; refraction of sunlight by raindrops to form a rainbow	Being	Ending	Beginning	<i>When</i>	<i>Time</i>
Cusp	$V=x^4$	Fault; geological fault; transitions from flight to fight, love to hate, and anxiety to calm in man and animals	Becoming	Capturing, Separating, Breaking	Engender, Uniting, Becoming	<i>Where</i>	<i>Location</i>
Swallowtail	$V=x^5$	Slit, crack; behavior patterns in some human nervous disorders; structural stability and buckling	Agitate	Rejecting, Tearing, Splitting	Crossing, Knitting	<i>Which (Whether)</i>	<i>Distinction</i>
Butterfly	$V=x^6$	Pocket, shell; structural stability and buckling	Give	Sending, Scaling, Exfoliating	Receiving, Giving	<i>How</i>	<i>Dynamic</i>
Hyperbolic umbilic	$V=x^3+y^3$	Arch; collapse of bridges; development of sonar devices	Cresting wave	Collapsing, Breaking (wave), Breaking down	Covering	<i>What</i>	<i>Typology, Taxonomy Nomenclature</i>
Elliptic umbilic	$V=x^3-3xy^2$	Needle, hair; flow of fluids	Penetrate	Piercing	Filling, Annihilating	<i>Who Whom Whose</i>	<i>Identity, Nomenklatura, Authenticity</i>
Parabolic umbilic	$V=x^2y+y^4$	Fountain, mushroom, mouth; atmospheric fronts; problems in the field of linguistics; elastic stability	Eject	Lancing, Pinching	Linking, Opening	<i>Why Wherefore</i>	<i>Reason, Symbolism, Auspiciousness Value Aesthetic</i>

As noted by Alexander Woodcock and Monte Davis (*Catastrophe Theory*, 1976):

These stable unfoldings are called catastrophes because each of them has regions where a dynamic system can jump suddenly from one state to another, although the factors controlling the process change continuously. Each of the seven catastrophes represents a pattern of behaviour determined only by the number of control factors, not by their nature or by the interior mechanisms that connect them to the system's behaviour. Therefore the elementary catastrophes can be models for a wide variety of processes, even those in which we know little about the quantitative laws involved. This is an extraordinary idea: how is it possible that two processes can have features in common even when they are on different physical scales, operate under different quantitative laws and are affected by different sets of causes ?

The table above serves (tentatively) to distinguish the WH-questions in terms of generic catastrophes:

- the first four questions deal primarily with operational **tangibles** -- through "when", "where", "which" and "how" (corresponding, in mathematical terms, to systems with only one behavioural variable and termed the cuspid series). They might notably be said

to be typical of the "project logic" characteristic of the majority of strategies in response to sustainable development. John Ralston Saul (*The Unconscious Civilization, 1995*) has criticized such "in-the-box" initiatives as not calling for imaginative thought on the part of those managing their implementation

- the second three questions deal essentially with **intangibles** -- through "what", "who" and "why" (corresponding to systems having two behavioural output variables or order parameters, with interaction between the order parameters in the second two cases). The first two might be said to be typical of the politics, networking and spin through which a plethora of projects are defined and funded in response to strategies of sustainable development.

Why-questions and the parabolic umbilic

It is the complexity of "why" (corresponding to the **parabolic umbilic**) -- with 4 input (control) factors, rather than the 3 factors in the case of "what" and "who" -- that might be understood as characterizing the dynamics of the **Council of the Whys**. The six-dimensional parabolic umbilic is difficult to depict except in very limited subsections (cf A N Godwin. *Three dimensional pictures for Thom's parabolic umbilic, Publications Mathématiques de l'IHÉS*, 40, 1971, pp. 117-138).

In seeking a correspondence between why-questions and Thom's "archetypal morphologies" in the table, it is interesting that both a **fountain** and a **mushroom** -- as traditional cross-cultural symbols of creativity, fecundity and innovation -- are cited as examples of the parabolic umbilic catastrophe (possibly to be understood as a form of conformal mapping). In a discussion on innovation, human creativity and complexity, Stephen J. Guastello (*Chaos, Catastrophe, and Human Affairs: applications of nonlinear dynamics to work, organizations, and social evolution*, 1995) explores the parabolic umbilic in relation to "mushroom catastrophe dynamics". This was found to explain the dynamics of creative problem solving in groups who were working together in real time in an experimental situation.

The approach suggests the possibility of analyzing why-questions in terms of "4 input control factors" and "2 behavioural output variables", notably as to the manner in which these offer greater creative degrees of freedom and potential for reframing. What indeed is the "shape" of a "good question", or a pertinent question -- its "goodness of fit"? How is "not the right question" recognizable? What makes for a "burning question"? For example, how "problematic" (perhaps in the light of complexity / chaos theory) does an experiential situation have to become before "why" is a more appropriate question than any other?

In particular such reframing may apply to:

- who: identity and "kinship" of both the "other" and, self-reflexively, the questioner.
- what: categories through which reality, and responses to it, are articulated

The failure of Thom's catastrophe theory to provide descriptions of systems with more than 5 significant variables can perhaps be related to the challenge of determining the nature of higher order questions "beyond" the limited set of WH-questions -- and the why-questions potentially describable in terms of the parabolic umbilic.

Pointers to comprehension of multi-dimensionality of WH-questions

As noted above, the multi-dimensionality of the catastrophes makes them difficult to depict except through particular subsections. These may even conceal the challenge of comprehension, especially when the dimensions may be interpreted either temporally or spatially. The few dynamic visualizations tend to be of quantitative rather than qualitative value. The following are therefore suggested as ways of coming to an understanding of the dynamics of WH-questions, and especially why-questions, in the light of ways of engaging with catastrophes variously understood.

A. Skateboarding pointers to comprehension of multi-dimensionality

It is curious, if not remarkable, that many who are readily framed as least likely to be interested in comprehension of WH-questions *per se* are to be found exploring highly complex surfaces by **skateboarding** over them to the limits of their kinetic skills. Skateboards first emerged, as a historical coincidence, within the same decade that Rene Thom was elaborating his theory. They are notably associated with a counter-culture that contests a particular consumer-oriented development of public commercial space and seeks to engage with that space in new ways (cf Ocean Howell. *The Poetics of Security: Skateboarding, Urban Design, and the New Public Space*, 2001). Their significance has been compared to that of the **Situationists**. The surfaces are constructed as skateparks by progressive local communities and public institutions, or (possibly more questionably) as commercial ventures. Some are of relatively simple configuration; others are highly complex [[more](#)]. The dynamic of movement through such a space is central to the geometry of skatepark design:

One of the most important elements of skate park design is flow. A skate park's flow determines how a rider transitions from one ramp to the next and how he/she moves from one area of the skate park to the next. Proper flow allows for beginner, intermediate and advanced session areas, each with several different ride lines. [[more](#)]

It would be worth exploring the jargon (cf Skateboard Science, *Skateboarding Glossary*) and skills (note the many **skateboarding tricks** of skateboarders) to determine the extent that they enact the behavioural characteristics of the dynamic systems with fold and cusp catastrophes. These are according to Zeeman (1977):

- Bimodality: if a system spends most of its time on either of two widely separated conditions
- Inaccessibility: when intermediate values between the conditions are inaccessible.
- Sudden jumps: if the system jumps from one condition to another.
- Hysteresis: if there is a cycle of jumping back and forth due to oscillations of the normal factor, but with the jumps not happening at the same point.

- Divergence: resulting from increases in the splitting factor with two parallel paths initially near one another moving apart if they end up in different conditions after the splitting factor passes beyond the cusp point (only in cusp catastrophes)

Given the kinetic gyrations of the most "aerobic" skateboarders, it is probable that they could well be exploring even more complex catastrophes. In the light of the categorization of forms of intelligence by Howard Gardner (*Frames of Mind: the theory of multiple intelligences*, 1985), is the kinesthetic (bodily/kinetic) intelligence indeed more capable of "comprehending" more complex catastrophes?

The skills of skateboarders certainly require a corresponding ability to consciously address other WH-questions: when, where, which, how, what, and who. With regard to "why", it might be argued that through the activity itself, skateboarders are effectively enacting the "why" in the social-political sense explored by Ocean Howell (*The Poetics of Security: Skateboarding, Urban Design, and the New Public Space*, 2001). Skateboarders might be said to be "skating the why" just as dancers of past cultures have enacted a reality that does not lend itself to verbal articulation.

B. Sexual attraction and intercourse as pointers to comprehension of multi-dimensionality

The relationship between sensory input regarding the human body and its movements, and their semantic implications, as described above by Wolfgang Wildgen (*Catastrophe theoretical models in semantics*, 2004; *Morphogenesis of limits: the relevance of dynamic systems theory for cognitive linguistics*, 2005) raise issues about the nature of attractors and repellers in interpersonal encounter in relation to the shapes of elementary catastrophes. Wildgen focuses only on a neutral subset of the range of Thom's archetypal morphologies in his investigation. The dynamics of arousal and intercourse have however been explored using catastrophe theory by H M Hubey (*Catastrophe Theory and Human Sexual Response*, 1991).

There is however the radical possibility that sexual attraction (or repulsion), as a fundamental behavioural discontinuity, is intimately related to psychological engagement with the spatio-temporal forms and patterns (as "catastrophes") of interpersonal encounter. This is exemplified by the discontinuity of "falling in love". To what extent is eye movement over the body of another associated with a response to forms that lend themselves to mathematical description as "catastrophes"? Human beauty has indeed been analyzed in terms of geometric proportion. The shapes of the body that are a focus of attraction can be closely related to the shapes descriptive of sections of the elementary catastrophes -- even without taking into account dynamics associated with them (cf Gurman Kaur, *Mathematics in the Nude*).

Curiously, Salvador Dali as a surrealist painter renowned for his attention to women, devoted several of his last works to topology, inspired by Rene Thom. As reported by Thomas F. Banchoff (*The Fourth Dimension and the Theology of Edwin Abbott Abbott*):

Salvador Dali's painting *Corpus Hypercubus* of Christ crucified on a hypercube, symbolizes the infinite folded down into the finite for our benefit... We do not see things completely; we only see them in their illusions. Dali's final painting includes inflection points, and a swallowtail catastrophe, which forms the image of a chalice, once again combining mathematics and theology.

One of Dali's final works was entitled *Topological Contortion of a Female Figure* (1983). It might be assumed that, as an artist, Dali recognized the relationship of the attractive shapes of the body of a woman to the forms of the elementary catastrophes. Of related interest are three poems of Mary Jo Bang (*The Eye Like a Strange Balloon*, 2004) on the topic of catastrophe theory.

As implied by T. van Gelder and R. Port (*Beyond symbolic: towards a kama-sutra of compositionality*. In: Symbol processing and connectionist network models in artificial intelligence and cognitive modeling : steps towards principled integration, 1994), is there a cognitive dynamic to interpersonal encounters of which the 64 positions of the *Kama Sutra* could be considered an enactable code for multi-dimensional understandings that cannot be verbally articulated? (cf Boris Saulnier, *Au-delà du représentationnalisme symbolique : la modélisation constructiviste et morphodynamique des systèmes, et le défi de la compositionnalité*, 2003). Such possibilities relate to the explorations of *tantric yoga*. Intercourse might then be understood as "dancing with discontinuity" and with the associated questions and answers -- expressed non-verbally through to their consummation and "semantic" union (cf O E Rasmussen. *The Dance of Meaning: the fundamentals of interpersonal reasoning and sense-making*. European Chaos/ Complexity in Organisations Network (ECCON), 2005) .

Such considerations can only be suggestively reinforced through an applet such as that of Lucien Dujardin (*Catastrophe Teacher: an introduction for experimentalists -- parabolic umbilic*, 2005) through which 4 control parameters can be variously controlled.

C. Multiple intelligences as pointers to comprehension of multi-dimensionality

There are many approaches to knowledge organization -- as helpfully compared in tabular form by Verna Allee (*The Knowledge Evolution: Expanding Organizational Intelligence*, 1997, *Appendix*). Allee's comparison includes models by Peter Senge, Erich Jantsch, Stafford Beer, Elliot Jacques, Russell Ackoff, Edward Deming, Abraham Maslow, Lawrence Kohlberg, Jean Piaget, Arthur Young, Ken Wilber, and Sharon Franquemont. The comparison is made in terms of seven categories: data, information (procedural), knowledge (functional), meaning (managing), philosophy (integrating), wisdom (renewing), and union.

Both the multiplicity of models, and the distinction of stages, phases or modes within models, is indicative of fundamental discontinuity in knowledge space -- however this is understood. Allee notes in particular the continuing influence of the 7-fold *chakra* system as one of the oldest such organizing systems for domains of intelligence (cf Rolf von Eckartsberg, *Maps of the Mind: the cartography of consciousness*, In: *The Metaphors of Consciousness*, 1981). The situation might well be described as a quagmire of competing alternatives with many of the models implicitly endeavouring to subsume others. It is possible that these discontinuities -- and the stability of the stages perceived -- could be fruitfully explored in the light of the elementary catastrophe forms.

To clarify the relation to WH-questions, the focus here is placed on the distinctions made by [Howard Gardner](#) (*Frames of Mind: the theory of multiple intelligences*, 1985; *Intelligence Reframed: Multiple Intelligences for the 21st Century*, 2000) [[more more more more](#)]. These are:

- linguistic intelligence: processing and using oral and written language
- logical-mathematical intelligence: including rationality and technical understanding.
- spatial / visual intelligence: processing of visual representations
- bodily-kinesthetic / motor intelligence: learning through touch, muscles, skin, balance, etc
- auditory / musical intelligence: deriving meaningful patterns while listening
- interpersonal intelligence
- intrapersonal intelligence: providing understanding of one's own needs and the capacity to satisfy those needs
- naturalist intelligence: relating to and making meaning of the physical world and environment

Gardner, and others, have also considered adding philosophical intelligence, spiritual intelligence, existential intelligence, moral intelligence, and others. It might be asked whether a particular intelligence is especially empowered to enable a response to a particular question. How is the thinking associated with a particular intelligence "formed" by such a question and by the catastrophe(s) to which it is required to respond? If that is the case, then the debate about "missing intelligences" in Gardner's set highlights the concern as to the possibility of "missing questions" in the WH set (cf *Council of the Whys: emergent wisdom through configuration of why-question dynamics*).

In exploring the relation of such distinctions to WH-questions, there are several approaches including:

- refining and constraining particular WH-questions so that they confirm less ambiguously to particular intelligences
- considering individual WH-questions to be more particularly, or primarily, associated with one (or more) modes of intelligence, where other questions are only of secondary significance
- clustering particular combinations of WH-questions which may then provide a better mapping to particular intelligences and to the associated catastrophe(s) to which they respond. This is illustrated by the following table.

Table: Combinations of WH-questions, potentially characteristic of particular modes of intelligence							
	Why	Who	What	How	Which	Where	When
Why							
Who							
What							
How							
Which							
Where							
When							

The elaboration of the above table derives in part from earlier work on such a tabulation (see *Set of measure formulae as a template for WH-questions* in: *Functional Complementarity of Higher Order Questions: psycho-social sustainability modelled by coordinated movement*, 2004) where the positions of "how" and "what" were interchanged. It was however triggered by the following comments of Peter Collins (personal communication) in relation to the [four quadrant](#) approach of Ken Wilber:

Using Wilberian terminology all phenomenal interactions can be explained in terms of the interaction of the four quadrants.... So we could then validly affirm that all of the WH-questions relate in varying manners to the interaction between the four quadrants. Clearly for some of the WH-questions the interaction would be very limited. For example "when" and "where" questions would largely relate (though not exclusively) to just one quadrant.

However... "why" questions are potentially much more complex and would entail a richer interaction of the four quadrants. For example if one poses the question: Why did John Lennon die, one could attempt to answer with an objective answer at an individual level e.g. because he was fatally wounded by a gunshot. However one could also attempt to explain it at a subjective individual level e.g. because his killer was motivated with the desire to achieve some kind of distorted recognition through the act. However one could also attempt to deal with the issue in (objective) collective terms e.g. that the freedom to hold guns increases the risk of such killings or perhaps in subjective (collective) terms that the cult of celebrity leads many mentally unbalanced people to act irrationally.

Therefore though earlier WH-questions can be largely dealt with in terms of one quadrant, more complex "why" questions entail a richer interaction of all 4. **So the four control parameters [of a catastrophe] would be the inputs four quadrants. The two behavioural outputs [of a catastrophe] would then relate to both the analytic (real) and holistic (imaginary) understanding emerging from this process.** [*emphasis added*]

Clearly the most creative endeavour would arise from the successful spiritual integration of the quadrants providing an overall (holistic) context for the creative interpretation of (analytic) phenomena.

The sequence of WH-questions of the above table has been ordered to define four (colored) "quadrants" which could prove to be consonant with those of Wilber:

- upper left: interior-individual (intentional) -- "I". Subjective-Individual. Defined above by 9 combinations of the higher-order WH-questions
- lower-left: interior-collective (cultural) -- "WE". Intersubjective-Collective. Defined above by 12 combinations of the 7 WH-questions
- upper-right: exterior-individual (behavioural) -- "IT". Objective-Individual. Defined above by 12 combinations of the 7 WH-questions
- lower-right: interior-collective (systems) -- "ITS". Interobjective-Collective. Defined above by 16 combinations of the lower-order WH-questions

The table as a whole might be considered as somewhat akin to the periodic table of chemical elements in identifying "groups" as adapted elsewhere (*Functional Classification in an Integrative Matrix of Human Preoccupations*, 1982) and currently used for subject access to [online databases](#). The "richer interaction" of WH-questions, for which Collins calls, would then amount to "molecules" -- memes -- combining elements from various parts of that table.

The earlier approach (*Set of measure formulae as a template for WH-questions*, 2004) suggests the correspondence of WH-questions to physical properties that would be significant in any further exploration of the correspondence to elementary catastrophes. Such measure formulae also provide greater connectivity to the physical dynamics of skateboarding.

D. Psychosis / Neurosis as pointers to comprehension of multi-dimensionality

Catastrophe theory offers a way of describing a variety of psychological systems that have conditions that are prone to suddenly "flipping" between states, instead of gradually moving between states in a linear manner.

There is continuing application of catastrophe theory to stage-wise cognitive development and sudden attitude change, including conversion. Work has been undertaken on the psychosocial dynamics of conflict-cooperation (cf R.J. Rummel, *A Catastrophe Theory Model of the conflict Helix, with tests*, 2002). The relevance to psychopathology has been recognized (*Major Principles of Ontogeny and Phylogeny*, Current Medical Diagnosis and Treatment in Psychiatry, 2005), including study of anxiety (cf Ivan M. McNally, *Contrasting Concepts of Competitive State-Anxiety in Sport: multidimensional anxiety and catastrophe theories*. *Athletic Insight*, 4, 2, August 2002). Possible applications of catastrophe theory to psychoanalysis have been explored, but with relatively little follow-up (cf R Galazer-Levy, *Qualitative change from quantitative change: mathematical catastrophe theory in relation to psychoanalysis*. *J. Amer. Psychoanal. Assn.*, 26, 1978, pp. 921 - 935; J Sashin, *Affect tolerance: a model of affect-response using catastrophe theory*. *Sociobiol. Struct.*, 8: 1985, pp. 175-202; Michèle Porte, *La dynamique qualitative en psychanalyse*, 1994). An annotated review of the more general literature relating to nonlinear dynamics in psychiatry has been developed by David M. Kreindler and Charles J. Lumsden (*Chaos and Psyche*, 2005) covering: metaphors and metatheories, neural networks in psychiatry, psychotherapy and phenomenology, disorder modeling (schizophrenia, mood and affect, personality), physiology

Anthony Stadlen, in a review of *Cassandra's Daughter: A History of Psychoanalysis in Europe and America* (1999) by Joseph Schwartz, notes:

Rene Thom's notion of science as "reducing the arbitrariness of the metaphor" is pertinent to Dr Schwartz's own view of science. And Christopher Zeeman's metaphoric geometry of cusps and butterflies is less arbitrary, and reflects more accurately, the experience of hysteresis, catastrophic change and transcendence than such metaphors as "vicious circle", or "another spiral of the dialectic", or "equidistant from id and superego", though these are good enough for many purposes.

A study by J Bradmetz (*A Topological Model of Epistemic Intentionality*, *Axiomathes*, 13, 2, 2002, pp. 127-146) focuses, beyond their linguistic and rhetorical uses, on the mental epistemic verbs *to know* and *to believe* that reveals a basic conceptual system for human intentionality and the theory of representational mind. Cusp and butterfly models were used to explore the formation of epistemic states. These treat *to believe* as an intermediate state which lacks stability and presents the delayed effect of hysteresis.

The preliminary nature of such applications does not preclude the possibility of their relevance to the study of mental states and behaviours associated with WH-questions. At issue however is the manner in which these mental states are personally experienced rather than externally described by observers (cf Denis Postle, *Catastrophe Theory: predict and avoid personal disasters*, 1980).

Can the onset and form of pathological states -- the pathways and sudden transitions of attitude -- be experienced in ways that can be informed by the forms of the elementary catastrophes? How might experience of these forms relate to the experience of repetitive or other dysfunctional processes of formulating WH-questions characteristic of such pathology -- in the "skatepark" of the mind and/or emotions? (cf Doris Lessing, *Prisons We Choose to Live Inside*, 1987)

E. "Games people play" as pointers to comprehension of multi-dimensionality

In discussing the communication problems resulting from the discontinuities between disciplines, Felix Geyer (*The Increasing Convergence of Social Science and Cybernetics*, 1996) argues:

One should not wonder about strange interpretations of concepts when one transfers research results from one field to another field. It is for this that the skill of communication comes into the game of science. One has to move to the language-and-cultural games people play, even when they are doing science. It is then effective to make uses of the knowledge and "know-how" of the human sciences. That includes the last level of complexity: ... on which the complexity can be measured by the availability of a language in which theories can be formulated and communicated between different disciplines to attack the problem in an

heuristic way;

The *Stanford Encyclopedia of Philosophy* reports on the plausibility of the statement by H Gintis (*Game Theory Evolving*, 2000) that "game theory is a universal language for the unification of the behavioral sciences." K Binmore (*Game Theory and the Social Contract*, 1998) is reported as having modeled social history as a series of convergences on increasingly efficient equilibria in commonly encountered transaction games, interrupted by episodes in which some people try to shift to new equilibria by moving off stable equilibrium paths, resulting in periodic catastrophes.

On a more personal level, the process of [transaction analysis](#) developed by Eric Berne (*Games People Play: the psychology of human relationships*, 1964/1996) and promoted by the [International Transaction Analysis Association](#), suggests that such games and transactions could be interpreted as stable patterns in a context of dynamic discontinuity -- namely catastrophes (see also Claude Steiner, *Scripts People Live: transactional analysis of life scripts*, 1975/1990; Larry McLauchlin, *Advanced Language Patterns Mastery*). For transaction analysis, the games are common counterproductive social interactions. Such games are clustered as one of a variety of [group-dynamic games](#) for which the same point could be made. This approach has been extended towards variants of "games played in groups" and "games organizations play" (cf Thierry Gaudin. *Les Katas Institutionnels*, 1977; Michael Maccoby, *The Gamesman*, 1976) [[more](#)]. The issue is the nature of the WH-questions implicit in any such transactional game and whether engagement in any game pattern is effectively the enactment of a question that might be understood as taking the form of an elementary catastrophe.

F. Strategy games as pointers to comprehension of multi-dimensionality

Games like chess and *go* are frequently associated with comments concerning the distinct "energy" or tensions characteristic of certain strategic conditions. A valuable description of this subtle perception is provided (in translation) by Michel Bruneau (*Dynamic Chess Classification -- Chess Theory*) which explicitly acknowledges how difficult it is to explain the meaning of "energy" in chess. The document distinguishes, and comments on, 7 game conditions:

- "Quick divergency"
- "Slow divergency"
- "Damped divergency"
- "Unstable"
- "Balanced"
- "Exhausted"
- "Aborted"

The document states that "chess energy" or "tension" is the result of various imbalances appearing on the chessboard during the unfolding of the game. Their brief description, in energy terms, of each condition -- as a discontinuity -- suggests an intriguing resemblance to geometrical descriptions of the 7 catastrophes. Their descriptions might be usefully refined by a chess-playing mathematician familiar with catastrophe theory. Such descriptions might also be usefully confronted with analogous descriptions by *go*-playing mathematicians (cf David H. Stern et al. *Modelling Uncertainty in the Game of Go*; Bruno Bouzy and Tristan Cazenave, *Computer Go: an AI oriented survey*, 2001).

The game of *go* (also known as *igo*, *wei ch'i*, or *baduk*) uses terms such as *aji* (literally "taste" or "flavor") meaning latent energy --- a long-term potential for good or ill that persists, ready for activation at the appropriate moment. There is the possibility that such conditions are especially associated with particular strategic questions -- as explored above. *Go* has been used as a research domain for cognitive science cf Jay Madison Burmeister, *Studies in Human and Computer Go: Assessing the Game of Go as a Research Domain for Cognitive Science*, 2000). In a discussion of the neural and cognitive aspects of *go*, Robert T. Myers and Sangit Chatterjee (*Science, Culture, and the Game of Go*, *Journal of Science and Culture*) indicate:

The symmetry, simplicity and the topological nature of the game of Go evoke great fascination on the part of mathematicians, physicists and people from every branch of science.... Typical professional Go players... almost certainly do not approach the game from a mathematical vantage point. Instead they appear to view Go as a highly pattern-oriented game, involving deeper and deeper trees of strategies and sub-strategies.... This has given rise to the intriguing notion that Go is in fact the classical AI problem that chess turned out not to be, that solving Go will in fact require approaches which successfully emulate fundamental processes of the human mind, and the development of these approaches may both give us new insight in to human thought processes and lead to the discovery of new algorithms applicable to problems ranging far beyond Go itself.... One key element would appear to be a pattern recognition and processing facility. Stronger amateurs and pros, when confronted with a local board position, can immediately point out the move considered to be "good shape" or "bad shape".

The game has been understood in terms of energy since its origins, as noted by Peter Shotwell (*The Game of Go: speculations on its origins and symbolism in Ancient China*, 2002):

...it would seem likely that the players of the first games of *go* would have been characterizing their play as attempts to block and release *qi* by placing their stones down on the board according to the tenants of *feng shui* (literally 'wind and water')... the *qi* of "energy".

The ability to sense such energy patterns may be related to the phenomenon of [synaesthesia](#) (cf Richard E. Cytowic, *Synaesthesia: phenomenology and neuropsychology -- a review of current knowledge*, 1995). A number of synaesthetes have had significant chess-

playing or mathematical ability (cf Vladimir Nabokov, Marcel Duchamp, Daniel Tammet). In this dynamic, patterned context, what might be "the shape of a question" -- or of the 7 distinct WH-questions, given their strategic importance in response to emerging "catastrophes"?

G. Meditation pointers to comprehension of multi-dimensionality

The previous possibilities provide a connection to understandings from disciplines of meditation with regard to "cognitive catastrophes" as sudden spiritual insights or "peak experiences", whether through the extensive contemporary explorations and syntheses of Wilber and others -- or through the traditional insights associated with [tantric yoga](#) (with respect to the [chakras](#)) or with comparable disciplines (cf [Navigating Alternative Conceptual Realities: clues to the dynamics of enacting new paradigms through movement](#), 2002). The issue is whether different stages or modes of meditation are especially associated with particular WH-questions that experientially take forms describable, or recognizable, as "cognitive catastrophes" (cf. Leslie L. Downing, *A Catastrophe Theory Model of Ideological Conversion and Commitment*, 2003).

If the meditation process is described as a cognitive activity in a multi-dimensional space, pathways defined by spiritual disciplines, as well as "mistakes" may, for example, have some recognizable correspondence for practitioners to the properties described (above) for fold and cusp catastrophes according to Zeeman (1977).

Aspects of this possibility have been explored by S. David Stoney, Jr. (*A Structure for Embodied Human Consciousness*, Society for Neuroscience Abstracts, 24:1419, 1998) with respect to the cusp and butterfly catastrophes.

To the extent that the meditation is understood and experienced as an energy activity, as in the case of the tantric yoga focus on chakras, a particularly interesting issue is the relationship sought between understandings associated with the "simplest" and most "complex" chakras -- expressed in terms of the coiled [kundalini](#). In terms of the multi-dimensional insights associated with catastrophe theory, this suggests the emergence of potentially higher forms of order than those associated with the elementary catastrophes. This could well be associated with yet higher-order questions (cf [Engaging with Questions of Higher Order: cognitive vigilance required for higher degrees of twistedness](#), 2004).

H. Symbolism pointers to comprehension of multi-dimensionality

The common symbol indicative of any form of WH-question is the [question mark](#). No distinction is made between types of question. It is interesting to reflect on how cultures that may have some sensitivity to the intimate relationship between a question and the associated nonlinear cognitive dynamics might choose to represent distinct WH-questions -- or the associated "cognitive catastrophe", however that is understood.

It is for this reason that it is worth noting the implications in the case of Sanskrit as one of the languages considered sacred. The [Vedas](#), for example, are written in Sanskrit -- considered to be "the language of reality". This derives in part from an understanding in the Hindu tradition that the forms of the letters of such a language are themselves embodiments of different patterns or movements of insight or energy -- cognitive, if not spiritual. For example, R.K. Joshi (*The Religious World of Letterforms Mediamatic*, vol. 8, 1996, #4) indicates:

Various writing systems either pictographic, alphabetic or syllabic in nature, developed in different parts of the world over different time-frames, have been associated with the spoken or written expressions of linguistic thoughts.... Yet many of these sign systems in the able hands of sensitive calligraphers or master writers reflected their inherent formal aesthetics through their well formulated structures, taking ordinary writing to the level of Art. At a still higher level, philosophies of writing have attributed certain sacred qualities to the written signs, even claiming spiritual experience through the ritualistic practice of writing. By taking the art of calligraphy to the sublime heights of meditation through the symbolic representation of deities in the form of letters (seed-syllables), written signs not only served to help acquire a knowledge base of the physical world around the human being, but also played an important role in their spiritual and metaphysical needs. Letterforms essentially aided communication with the unknown via the primal energy behind their worldly manifestations.

This understanding in relation to calligraphy, and associated meditation, is common to a number of traditions, including the Coptic Gnostic, the Jewish Kabbalistic, Tibetan, Zen, and Tantra (in its highest form) where they may be used in the construction of integrative mandala-type images. It is suggestive of their common role that "germ" and "seed" are terms common both to the mathematics of the generation of the different forms of catastrophe and to the focal denotations of the individual [chakras](#) and their associated energy patterns (as [bija](#)).

It is therefore tempting to consider the question mark as a "generic" version of the cognitive shift associated with the signs traditionally central to the 7 chakras (and a focus of meditation on them) -- and considered here (as argued above) as having a possible correspondence with the individual WH-questions. In the case of chakra symbols, the so-called "petals" surrounding each might be considered indicative of the dimensionality of the associated catastrophe.

There is the interesting possibility that other traditions of mathematics, as noted by ethnomathematicians, may have developed forms of representation more suited to "seeing" catastrophic forms and viable pathways of continuity through them. For example Bill Barton (*Ethnomathematics and Philosophy*, 1999):

For example, consider the traditional questions in the philosophy of mathematics: how do we come to know about mathematical objects? But if the way we talk about number or space uses action words, how are we to make sense of a question about mathematical objects? ... Those of us with conventional mathematical back-grounds tend to think in rectilinear grid systems - our

graphs are drawn with axes as verticals and horizontals, our talk is full of 'ups and downs'. Many weavers of indigenous crafts, however, orient themselves to diagonal systems: weaving on the diagonal is an easier technique in many situations. What mathematical functions would interest us if our graphs were drawn using diagonal axes?

Pattern of symbols in relation to WH-questions (very tentative -- in process ***)								
?								
	WH-questions	Why	Who	What	How	Which	Where	When
	Why							
	Who							
	What							
	How							
	Which							
	Where							
	When							

The cells of the above table, following earlier investigations (*Functional Complementarity of Higher Order Questions: psycho-social sustainability modelled by coordinated movement*, 2004), can be populated by understandings of question combinations. Thus row-heading questions can be combined with column headings (eg of the type *Why/How*) to populate the lower-left quadrant -- or the reverse (eg *How/Why*) to populate the upper-right quadrant. This suggests an inversion of the dominant and subordinate role for the two original WH-questions in each case.

As a tentative illustration, a zodiacal symbol is used (to be understood differently in each quadrant) -- given the possibility that these forms offered traditional mnemonic reminders of the forms of the question in each case (as argued with respect to the *chakra* letters). There is an interesting possibility to be explored that the form of the constellations were used by cultures of the past to hold such reminders of the "form" of the challenging questions required for psycho-social sustainability (cf Edward Matchett and George Trevelyan, *Twelve Seats at the Round Table*, 1976). The challenge of encoding cultural insights in this way to protect them against erosion of social memory has been explored elsewhere (*Minding the Future: a thought experiment on presenting new information*, 1980; *Societal Learning and the Erosion of Collective Memory*, 1980).

One approach to providing symbolic content to the 16 cells of the lower-right quadrant is to use the codes of the *Myers-Briggs Type Indicator* which is derived from combinations of the the 4-fold set of psychological functions identified by C G Jung. However since no mnemonic cultural symbols are used to identify these combinations, one alternative is to use the tetragram coding -- a reduction of the *I Ching* hexagram. The octagram, doubling the tetragram, is used in the case of the *Tao Te Ching*. Note the widespread use of *n-grams*, including the quadrigram (*Research on N-Grams in Information Retrieval*, 1997; Valeri F. Venda, et al. *Cognitive Ergonomics: Theory, Laws, and Graphic Models*, *International Journal of Cognitive Ergonomics* 2000, Vol. 4, No. 4, pp. 331-349). Geometrically *n-grams* are represented by *star polygons*. In the *I Ching* hexagram a "moving line" may occur where a solid line shifts to a broken line (or vice versa) transforming one hexagram condition into another. This convention is of potential interest for indicating relationships between the cells in the lower-right quadrant as a result of "movement" in the lines denoting the conditions -- thereby delineating pathways between the cell conditions (cf *Transformation Metaphors (I Ching): dialogue, vision, conferencing, policy, network, community and lifestyle*, 1997),

With respect to the upper-left quadrant, potentially relevant is a modern organization of 9 distinct modes of intelligence provided by the *enneagram* (cf A G E Blake, *The Intelligent Enneagram*, 1996). However, despite its reputed origins, no distinct symbols are used to distinguish the nine individually within the symbol that frames their relationship. There are however two distinct sets of 9 symbols that merit consideration for that quadrant:

- A key Sanskrit work, *Natya Shastra* ("Scripture of Dance") deals with the different arts used to express feelings: primarily music, dance, literature and theater. It is the foundation of the fine arts in India, notably through distinguishing the *rasas* as forms of emotion susceptible to artistic expression: *Adbhuta* (Wonder), *Hasya* (Laughter), *Shringara* (Love), *Shaanta* (Peace), *Bibhatsa* (Disgust), *Vira* (Valour), *Karuna* (Pathos), *Bhaya* (Fear) and *Raudra* (Anger). (NB According to Bharata, there were 8 *rasas* and this was accepted until the first commentator on *Natya Shastra* began to speak of the *rasas* as nine in number). They were further articulated by *Jagadguru Badshah* (*Book of Nine Rasas*) who is renowned for having sought to bring cultural harmony, between the Shiyas and the Sunnis and between Hindus and Muslims through music.

With regard to *rasa*, Vilayanur S. Ramachandran (*The neurological basis of artistic universals, Art and Cognition*) argues that: "This Sanskrit word is difficult to translate but it roughly means "Capturing the very essence, the very spirit of something, in order to evoke a specific mood or emotion in the viewer's brain"... I realized that if you want to understand art you have to understand what *rasa* is and how it is extracted by the neural circuitry in the brain".

- In Greek mythology, the Muses are nine archaic goddesses who embody the right evocation of myth, inspired through remembered and improvised song and traditional "music" and dances. They are: Calliope (epic poetry), Euterpe (music), Clio (history), Erato (lyrics/love poetry), Melpomene (tragedy), Polyhymnia (sacred poetry), Terpsichore (dancing), Thalia (comedy), and Urania (astronomy).

In each case the argument is that it is these symbols that are carriers of cultural insight into the nature and "form" of a particular cognitive discontinuity -- a particular dance between question and answer, between questioner and answerer. (Note that such an approach has been the subject of a variety of speculative experiments and proposals [[more](#) | [more](#) | [more](#) | [more](#) | [more](#)]). Nick Herbert (*Quantum Reality: Beyond the New Physics*, 1987) suggests that:

One of the greatest scientific achievements imaginable would be the discovery of an explicit relationship between the waveform alphabets of quantum theory and certain human states of consciousness.

Psychosocial implications of WH-questions as "catastrophes": when, where, which, how

The set of WH-questions can now be tentatively explored in terms of their potential psychosocial implications -- assuming that the above argument for the relationship with the elementary catastrophes has a degree of validity.

When-question: Here the focus is clearly on timing and its unpredictability -- a one-dimensional concern. This is the domain of a "[fold catastrophe](#)". It can be understood as "the start of something" or "the end of something", in other words as a "limit", whether temporal or spatial. It concerns the sudden transition between one condition and another. It has no "cusp" point in contrast to the other catastrophes.

In the case of an ecosystem under stress, when its assimilative capacity is exceeded, it enters a condition of "metastability" -- a region of potentially rapid transition triggered by even a minor disturbance. Examples include:

- gradual increases in nutrients transforming an oligotrophic into a eutrophic lake,
- overgrazing transforming a grassland into a desert scrub ecosystem,
- overfishing causing the sudden collapse of a fishery.
- goods and services that are assumed in an economic model are no longer available; the assumptions of the economic model are no longer valid.

In effect the system jumps from one stable equilibrium to another without the intervention of a major external disturbance. All catastrophes are generically described by fold catastrophes. **Much concern about the condition of modern society and the planet may be described in terms of the triggering of such catastrophes** -- hence the [precautionary principle](#). This is the challenge of "when" any system -- personal, group, culture, ecology -- may "flip", possibly irreversibly, into a new mode (cf *Spontaneous Initiation of Armageddon -- a heartfelt response to systemic negligence*, 2004). That mode could of course be more desirable -- for some.

Where-question: Here the focus is on location. As a "[cusp catastrophe](#)", this is the spatial extension of the fold catastrophe -- into four dimensions. The cusp is a pleat, a fault; its temporal interpretation is "to separate, to unite, to capture, to generate, to change". It is the point at which a curve crosses itself. The catastrophe has a single cusp point -- the point of coming together of two folds in a sharp spike like intersection. A cusp catastrophe provides for a smooth, slow transition from one condition to another as well as for a fast discontinuous transition. The notion of a "cusp of change" describes a significant place of transition.

The cusp catastrophe has for example been used to model the dynamics of brain processes resulting in occasional epileptic seizures [[more](#)] or the behaviour of a stressed dog, which may respond by becoming cowed or becoming angry.

Its relevance to policy analysis is highlighted by Lorraine Dodd and Mark Round (*Assessment of intervention actions for HIV/AIDS*, 2004) concerned with the basic requirement for the analytical methods in determining the appropriate relationship between social and political coherence and the experience of pandemic disease. The main question is then, for analytical methods: what are the appropriate modes of analysis to grasp these diverse data and make them tractable for effective policy response? In a description of the challenge of understanding the control space, the authors note:

Three-dimensional cusp models can be used to understand the control space provided that the system has what is known as a "gradient dynamic" -- that is, we are always trying to minimise some function such as cost or loss, and that there are two variables controlling this gradient. A vital element of a cusp catastrophe model is that it shows there is a range of values of the control parameters, where small continuous increases or decreases in them can result in large fluctuations in behaviour. For example, we could define the two control parameters as follows:

- a: system stress (level of uncertainty and trust in the situation attributes plus number of conflicting cost assessments and conflicts of interest)
- b: need for intervention action (criticality depends on mis-match between perceived current situation and desired situation).

Put simply the two control parameters represent, respectively, the system's unpredictability/complexity and the magnitude of the

'stakes' if intervention actions fail (or if no action is taken).

In effect such an approach addresses the where-questions: where to intervene and where to go in navigating the collective decision-space. Such concerns also apply in the study of individual human stress by Peter A. Levine (*Accumulated Stress, Reserve Capacity, and Disease*):

The underlying theme of this paper is that the accumulation of stress affects the reserve capacity of an organism, both in the maintenance of its functional integrity and in the resolution of subsequent exposures to stress... The basic physiologic relations of the autonomic, sympathetic and parasympathetic, can be represented by a simple mechanical analogy... which exhibits properties described by a relatively new branch of mathematical topology, catastrophe theory. The visualization gained by this re-presentation offers new insights into the nature and mechanisms by which stress accumulates. It also suggests "paradigms" by which stress, once it has already become internalized, may be successively resolved towards re-establishing a fuller adaptational range/reserve capacity.

There are several different kinds of cusp catastrophe of varying shapes and applications. The classic model is essentially a potential well - a gravity well -- usefully understood as a 'strange attractor'. It is effectively a system that moves in a continuous loop within a defined space around one or more poles -- without making exactly the same loop twice. The irrecoverable state is then expressed as a loop initially traveling around two poles (violent and nonviolent), with the loop eventually settling around a single pole. More directly, it can also be expressed as a sort of 3-dimensional descent down a mountainside -- from one state to another -- with bumps along the way.

Clearly this could also be used to model a progressively converging movement of the eyes in response to an attractive feature of a human body. There are applications of such models to marketing and consumer catchment areas -- including the challenge of switching between products. In the case of larger social policy issues, it clearly has relevance to switching between potentially dangerous attractors (unrestricted consumption of non-renewable resources, gated communities) and alternative attractors (quality of life, etc) -- or the reverse. **The challenging where-question remains that of determining the pathway -- whether into or out of any place of power (or opportunity) or a "Garden of Eden".**

Which-question: Here the focus is on the modelling capacity of the *swallowtail catastrophe*. In the terms of Ole Elstrup Rasmussen (*The Discontinuity of Human Existence*), this third order catastrophe consists of a three-dimensional agent surface that determines a four-dimensional surface of objective. This catastrophe has two cusp points, in contrast to the single point of the cusp catastrophe. These bifurcation points of the surface of objective projected on the agent surface, given certain conditions, resemble the swallowtail. The control dimensions which constitute the agent surface of the model are attention, positioning and intention. Rasmussen uses it to model "human existence subsisting as development".

Stephen J. Guastello (*Nonlinear Dynamics in Psychology*, 2001) points to the value of the swallowtail model in relation to the which-question of decision-making:

The formation of roles would constitute fitness peaks, which denote relative fitness, local stability, and clusters of similar subspecies with regard to shared adaptive traits. The probability density function that is associated with the swallowtail catastrophe model ... describes the distribution of people into unstable and locally stable social roles. The swallowtail catastrophe structure contains a response surface of discontinuous events, or qualitatively different outcomes, such that there are two stable states, with a minor antimode between them, an unstable state, and a major antimode separating the unstable state from the two stable ones.

In the abstract of a later paper, notably summarizing his earlier work, (*Leadership Emergence in Coordination-Intensive, Creative Problem Solving, and Production Groups*, 2006) this is more specifically highlighted in response to the which-question decision processes through which a leader is identified::

In self-organizing processes, a system acquires a structure without any external intervention. This presentation describes the process by which an initially leaderless group differentiates into one containing leadership and secondary role structures and how the process was aptly described by the swallowtail catastrophe model. A subsequent study identified the control variables in the process of leadership emergence in creative problem solving and production-oriented groups which were found to be different in the two cases. The third study, which is considered in greater depth here, examined a different case of coordination-intensive groups. Coordination-intensive groups are particularly interesting because it is known that coordination can occur without talking and without leaders present, even though talking helps in some respects. Coordination is also interesting because it is a nonlinear dynamical process all by itself

The three control parameters of the swallowtail catastrophe were thought to be related to asking questions, making jokes, initiating a line of discussion, clarifying points made in a discussion, diffusing conflict, following others, and "gate keeping" (cf Stephen J. Guastello, et al, *A Rugged Landscape Model for Self-Organization and Emergent Leadership in Creative Problem Solving and Production Groups*, *Nonlinear Dynamics, Psychology, and Life Sciences*, 9, 3, July, 2005, pp. 297-333)/

A swallowtail catastrophe was determined to be the most appropriate means of dynamically modeling the macro features of a natural resource / environmental (pollution) system in relationship to the economic system. Under a given mode of specific change of economic activities, the related policy parameters were shown to have to satisfy some requirements to avoid a catastrophic shift (Liu-jun Chen and

In the light of the work of Guastello, **it might be asked whether the swallowtail catastrophe is the most appropriate to model decision-making in leading to emergence of alternative communities -- or lifestyles.**

How-question: Here the focus is on the effective navigation of a strategic space. The **butterfly catastrophe** can be considered as a metastable state that is transitional between the two main stable states -- namely the system can exist dynamically in that transitional condition for a time before entering one of the stable conditions. In the terms of Ole Elstrup Rasmussen (*The Discontinuity of Human Existence*), the fourth order butterfly catastrophe is so termed, because, under certain circumstances, the projection of the surface of objective onto the agent surface resembles one. It is the first to exhibit a plane of bifurcation points. It is a swallowtail catastrophe with an extra control dimension. Because of the added control dimension, the agent surface becomes four-dimensional and the surface of objective five-dimensional. This type of catastrophe is quite impossible to illustrate. He uses it to model "human existence subsisting as correlation". He suggests that the complicated movement modelled by this fourth order catastrophe is the agent identifying the identity of objective. With respect to the practicalities of the how-question, he helpfully argues:

Identifying is an infinite process. The concept, however, is a momentarily finite process which encompasses the categories that are identified. This means that none of the categories being identified disappear: they are embedded in the concept. Because of the distance, the categories still exist as different from each other... The categories exist in time and space, but, as they are also identified because of the correlation prerequisite, the concept encompasses identifying as identity... The most common example of identifying dissimilar categories is the process of buying and selling, that is, trade in the market place by simple exchange of commodities. Because of the exchange, the commodities are distributed in the network in a new manner. Things and information change position in the network following the rules that are determined by canalization.... Because of the exchange in the market place, a sack of potatoes and a chair, for example, change places in the network, but in the same process they are identified and systematized in the concept of commodity. The farmer exchanges his potatoes as a commodity with the carpenter's chair, which is also a commodity.

The how-question may be considered as intimately related to the following research themes:

- **language:** Enrique Bernádez (*On the Study of Language with the Tools of Catastrophe Theory*. *Atlantis*, 1995) indicates that a butterfly catastrophe is the kind of process found in all situations involving compromise, whether in political life or biological development "or in the opposition of two adjectives of the type *black-grey-white* and the like, with two extremes and an intermediate, usually badly defined 'compromise' state with rather fuzzy borders."
- **motivation:** S J Guastello (*A butterfly catastrophe model of motivation in organizations*, *Journal of Applied Psychology*, 72, 1987, pp. 165-182) who studied the efficiency of the butterfly catastrophe model for describing and predicting performance changes in an educational setting.
- **willingness to work:** Daniel C. Kuang and Jenny C. Kuang (*Cusp, Quasi-Cusp and Butterfly Catastrophe Models of Employee Strike Willingness*, 2002 SIOP Conference) The butterfly catastrophe effectively unified the complex and multidimensional strike willingness construct. Union and organizational strategies in contract negotiation naturally emerged from the developed models. Procedural justice is predicted to mediate strike willingness decisions.
- **driving a vehicle:** Furutani, Naomichi (A New Approach to Traffic Behaviour: III. Steering Behaviour and the Butterfly Catastrophe. In *International Journal of Man-Machine Studies*, 9, 1977, 2, pp. 233-254)
- **dynamics of bilingualism:** Ernest Querol (*A New Theoretical Model for the Study of Bilingual Contexts: the Catastrophe Theory*) identifies the number and type of variables determining the use of a language since discontinuities are the key factor in determining language shift for monolingual speakers of either language (or a third) and for bilingual speakers having a bias towards one language or the other. The processes of language shift are described in terms of the stages of the butterfly catastrophe with a clear identification of the control factors.
- **competence development:** Jytte Bang and Ole Elstrup Rasmussen (*Competence Development Learning by Problem Solving*, *Cognitive Science Research*, Lund University, 2000, No. 74) point out that in order to explain different forms of problem-solving performance, it is no longer necessary to assign different attributes to persons who perform differently in complex situations:

The five-dimensional butterfly-catastrophe demands a four-dimensional control space. The two remaining control parameters, feeling of availability and achievement, are assumed to constitute the needed parameters. This means that it is availability and achievement in connection with efficacy and ruggedness which give rise to the third type of performance, muddling through. In generating the butterfly catastrophe, one state variable (the likelihood of performance) and four control parameters are needed (the normal factor, efficacy; the splitting factor, ruggedness; the bias factor, achievement; and the butterfly factor, availability).
- **qualifications for a task:** Ole Elstrup Rasmussen and Jørgen Aage Jensen (*Preparations for Modelling the Relationship between Competence and Qualifications*. *Cognitive Science Research*, Lund University, 2000, No. 77) were concerned to operationalize the control parameters and behaviour forms in terms of the cusp and butterfly catastrophes:

- distinguishing performance features indicating the different forms of performance
- distinguishing features that may indicate the conflicting control parameters efficacy and ruggedness
- plotting the relation between these groups of performance features
 - competence reflected in the problem setting, manifesting itself in the decisions made (as expressed in the establishment of the unit of meaning), with development of competence expressed in the change of the unit of meaning.
 - enactment of qualifications, reflected in the problem solving, manifesting itself in the choices made.

In terms of behaviour, they infer from their study that "roaming" could be seen as a fairly direct expression of the relationship, whilst another interesting path is from "digging in" to "lingering" to "ensuring the change of competence" that could make such a path possible. Comparing paths, that from "roaming" to "exploring" would imply changes in both of the control parameters; that involving a catastrophic jump from "roaming" to "digging in", implying a constant ruggedness, but a large change of efficacy.

- **emulsion inversion:** A butterfly catastrophe model has been applied to mimic dynamic inversion in emulsions. Psychosocial analogues could be envisaged (including willingness to strike)

In the light of the above, **the how-question in relation to (global) governance within the current mindset, might be more effectively addressed through the butterfly catastrophe model.**

Psychosocial implications of WH-questions as "catastrophes": what, who, why

As illustrated by the challenges of operationalizing parameters for the butterfly catastrophe, as well as the difficulty of comprehending (let alone visualizing) the more complex umbilic catastrophes, there is almost no research on the applicability of such models to the social sciences. One isolated example is an analysis by Puu (1979) of the structural change in regional trading systems using the five dimensional hyperbolic and elliptic umbilic catastrophes. The lack of such research inhibits reflection on their value in psychosocial situations.

Such catastrophes are commonly observed in optics in the focal surfaces created by light reflecting off a surface in three dimensions and are intimately connected with the geometry of nearly spherical surfaces. As catastrophes their geometric forms have in common, and are distinguished from others, by possessing a point on a surface at which the curvature is the same in any direction.

Seemingly more interesting than the "objective" optical examples are the far more subjective aspects of the what-, who- and why-questions through which humans define and relate to their environment -- as key processes in the progressive "construction of reality", whether as a social or individual enterprise.

What-question: Here the focus should be on how this question might be clarified by the [hyperbolic umbilic catastrophe](#). The what-question, as framed above, is concerned with distinguishing and identifying patterns, objects and entities in knowledge space -- defining (or imposing) meaningful boundaries. This process is not simply constrained by sensory input regarding entities distinguished as tangible "objects". It may include intangibles such as conditions, patterns of behaviour or meaning. What-questions call for the allocation of what is distinguished to some part of an organizing framework, a typology or taxonomy, or some other construct that provides a form of nomenclature. The what-question expects labels following the detection of a degree of invariance. It is fundamental to information classification, knowledge organization and its management -- irrespective of the degree of illusion underlying the process.

In addition the what-question is concerned with moving beyond the constraints of patterns and sets of categories considered inadequate to interaction with emerging conditions. In this sense it is associated with processes of creativity and innovation through which new objects and patterns are designed -- whether tangible objects (art or technology) or intangibles (including theories and aesthetic effects). This innovative aspect is significantly dependent on thinking "out-of-the-box", namely engaging in the kind of [lateral thinking](#) required to respond creatively to threats and opportunities. It is therefore to some degree associated with "new thinking" and enabling "paradigm shifts".

Given this focus of the what-question, it might be asked what relation this bears to the multiplicity of studies on light and radiation diffraction in terms of the hyperbolic umbilic catastrophe. Yet, if the challenge of human understanding of a confusing reality (with "the light of knowledge") is compared with the considerable challenge of detecting patterns of order in a crystal using x-ray analysis, then the possibility of a degree of isomorphism between the pattern detection of the what-question and such light diffraction studies merits exploration. Depending on how information is understood as being distributed in knowledge space, the hyperbolic umbilic may prove to be a valuable means of deriving significance from it. It may actually serve to "throw light" on the matter. There is a case for understanding the significance of "information diffraction" patterns, and the emergence of disciplines as a consequence of "knowledge diffraction" patterns.

The geometry of the [hyperbola](#) basic to the catastrophe is interesting in relation to understanding of the challenging relationship of subject-object, question-answer, etc. It offers two perspectives, corresponding to the two focal points:

- centering "objective" perspective at one focal point, the "subjective" perspective is inaccessible; centering "subjective" perspective at one focal point, the "objective" focal point is inaccessible
- the hyperbola is the locus of all points whose distances, x and y , from two fixed points, A and B , is a constant difference, $y - x = k$

Different philosophies favour one or the other stance to different degrees, typically disparaging the other as ill-founded or illusory. The perspectives are oriented in completely opposite directions -- however complementary they may appear to others. The challenge lies in the nature of the relationship, defined by the geometry of the hyperbola, between features centred on one focal point and features centered on the other. Whether "objective" reality is considered primary and the "subjective" secondary (or "subjective" reality is

considered primary and the "objective" derivative) is of less consequence than the relationship -- of reflection -- maintained between the two. The hyperbola also provides interesting geometry through which to explore the implications of a "shadow", understood in Jungian analysis as the dark, hidden side of the human psyche. In effect, whichever curve of the hyperbola is privileged, it is "shadowed" by complementary perceptions associated with the other.

The what-question can then be variously answered depending on the part of the geometry from which it is posed. Of great interest is the capacity of the hyperbola (and the hyperboloid) to function as a template interrelating polarized perspectives twisted in relation to each other (see below).

To the extent that a form of "binocular" conceptual vision is possible within the "objective" reality, this hyperbolic model might be used to explore classic cultural situations (cf C P Snow (*The Two Cultures and the Scientific Revolution*, 1959; Samuel P. Huntington, *The Clash of Civilizations and the Remaking of World Order*, 1998). It corresponds to the understanding of "seeing with two eyes" (cf John Polkinghorne, *Seeing with Two Eyes: Mutual Harmony between Science and Religion*, 2004; John A T Robinson, *Truth is Two-Eyed*, 1979; Magoroh Maruyama, *Peripheral Vision: polyocular vision or subunderstanding?*, 2004) [more].

The hyperbolic umbilic might therefore serve to map the basic "self-other" conditions, associated with the what-question, through its potential to reframe approaches -- through a degree of twistedness -- to the many polarized situations (and the dynamics of polarization) now tretching the fabric of society to tearing point.

Who-question: Here the focus should be on how this question might be clarified by the [elliptic umbilic catastrophe](#). The who-question, as framed above, is concerned with detecting and distinguishing identities in psychosocial space. Beyond the preoccupations of the what-question, it is thus concerned with identifying and relating to "significant others" whether in kinship networks, communities or as enemies from other groups. It is also concerned with the identity of the questioner -- the "who am I" question so important to self-esteem, religion and philosophy -- and the challenge to provide a credible answer to the "who are you" question asked by others.

In society, issues relating to the who-question are the focus of a variety of disciplines:

- marketing is concerned with the manner in which products and services define and enhance the identity of the individual or group (as consumers or voters), notably as fashion statements
- public relations is especially concerned to frame and enhance the identity of an individual or a group -- the processes of "image management" vital to the life and survival of celebrities and to sustaining their self-image, or re-inventing it
- psychotherapies of every kind are concerned with assisting the individual to better understand who they are, who they can become, and how they can best relate to others
- those concerned with the complex processes in society that come into play in response to those who distinguish themselves as heroic, saintly or demonic exemplars -- or may be promoted as such

Given this focus of the who-question, it might be asked what relation this bears to the multiplicity of studies on optical image analysis, light scattering (including backscattering and twinkling), and the study of diffraction patterns (in association with those modelled by the hyperbolic umbilic catastrophe) [more more]. The concept of psychosocial identity is a complex and subtle one -- often especially for the entity concerned, whether individual or collective (cf J. P. Cornelissen, *On the 'Organizational Identity' Metaphor*, 2002). It is perhaps not surprising that "light" is frequently used as a metaphor to describe issues of identity:

- in the "light" of public opinion
- the "limelight", notably in performances
- media "spotlight"
- "light" as a metaphor in redemption in religion -- "enlightenment", "I am the light"
- "light of awareness" emerging through education and individuation processes

The range of light-based metaphors used in discussion of aspects of identity and image, of the entity or of others perceiving it, again suggests the possibility of a degree of isomorphism with the optical focus on light (and blurring), including complex challenges of image analysis, which merit exploration. Depending on how identity knowledge is understood as being distributed in psychosocial space, the elliptic umbilic may indeed prove to be a valuable means of deriving significance from it -- as a "container" for quite distinct perspectives (and in striking contrast to the hyperbolic model). It may actually serve to address a range of challenging issues of identity -- whether individual or collective (cf [Quotations about Light](#)).

The secondary forms of the why-question, the whom-question and the whose-question, raise interesting issues in this context, notably regarding the meaning of possession and property, especially intellectual property and the notion of home(land). What possibilities are there for reframing "who" in these extremely sensitive conditions -- and how can the elliptic umbilic facilitate their identification?

The geometry of the [ellipse](#) basic to the catastrophe is interesting in relation to understanding of the challenging relationship of identity -- defined either in individualistic terms or in social terms. Like the hyperbola, it offers both these perspectives, corresponding to the two focal points:

- centering "individualistic" identity at one focal point; centering "social" identity (within a community) at a second focal point
- the eclipse is the locus of all points whose distances from the two fixed focal points have a constant sum

The ellipse is then the locus of combinations of individual-social identity in relation to those two points -- a pattern of degrees of hybridization. The ellipse may of course have a variety of forms (including circular) depending on the dimensions of the major axis relative to the minor axis -- suggestive of the relative importance attached to the individualistic or social understanding of identity. The who-question can then be variously answered depending on the part of the geometry from which it is posed. The need to combine the perspectives, as with the requirement for two eyes to achieve stereoscopic vision, is also indicative of the importance of both focal points to the dynamic positioning of an identity within psychosocial space.

Through the elliptic umbilic model the who-question might be more effectively addressed by its capacity to reframe identity as shifting continuously around (and changing its basis between) two extremes -- individual-collective, self-other, etc

Why-question: Here the focus should be on how this question might be clarified by the [parabolic umbilic catastrophe](#). The why-question, as discussed above, is concerned with new understanding -- potentially outside a framework immediately meaningful to the questioner. It relates not only to the "external" world of objects and processes, however they have been defined, but also to the "internal" condition of the questioner -- whether in existential, ethical, moral, philosophical or spiritual terms. At its most fundamental, it may seek to focus on the question of "why am I (alive)".

In society, issues relating to the why-question are the focus of a variety of disciplines including:

- [market research](#) (notably through opinion surveys) seeks to determine why particular products and services are purchased (or policies are supported)
- [motivation research](#) seeking to understand, from a psychological perspective, the internal state or condition that activates behaviour and gives it direction, desire or want
- vocational guidance research seeks, in part, to respond meaningfully to a person's question as to why they should engage in society
- values research seeks to understand the values and principles that determine individual and collective action
 - marketing (cf Simon Manyiwa, *Controversies in Values Research: methodological implications*)
 - ethics [[more](#)]
 - self-presentation
 - lifestyle / cultural creatives [[more](#)]
 - values databases [[more***](#)]
- experiential / lifestyle research seeks to understand why individuals or groups engage in alternative lifestyles and are able to sustain them:
 - [flow experience](#), as explored by Mihaly Csikszentmihalyi
 - happiness (cf J. C. Sprott, *Dynamical Models of Happiness*, 2005)
- philosophy is much preoccupied with the why-question and how it may be meaningfully answered:
 - Sandro D'Onofrio (*The Metaphor of Light and the Active Intellect as Final Cause*)
- theology / religion seeks to respond to the why-questions of generations of followers in the light of understanding of the belief system
 - spiritual direction
- ideology
- ethical frameworks:
 - global ethics [[more](#)]
- mythology / creation myths:
 - Joseph Campbell (*Myths of Light: Eastern Metaphors of the Eternal*)
- [wisdom](#):
 - [Collective Wisdom Initiative](#)
- attractors **** scarcity ***

The geometry of the [parabola](#) basic to the catastrophe is of value in understanding the challenging relationship of the questioner to the space-time manifold in which he/she is located and/or moving. It has three significant attributes:

- the focal point, that may be considered the locus of the questioner
- the vertex, positioned equidistantly between the focus and the directrix.
- the directrix, namely the line which, together with the focus, serves to define a conic section as the locus of points whose distance from the focus is proportional to the horizontal distance from the directrix (perhaps to be understood as the axis of grounded reality).

Metaphorically, these **attributes of the parabolic umbilic offer a means of ordering understanding in response to the why-question from a wide variety of philosophical, ideological and spiritual standpoints** -- especially if consideration is given to the orientation of the parabola (for example in relation to the symbolism of the [holy chalice](#)). The why-question can then be variously answered depending on the emphasis placed on particular parts of the geometry.

Interrelating cognitive catastrophes in a "Grail-chalice" proto-model

See [Annex](#)

The possibility of interrelating a representation of the elementary catastrophes in a "Grail-chalice" proto-model is discussed in an [Annex](#) with the following contents:

- [Introduction](#)
- [Cyclic patterning of WH-questions: vital cognitive self-reflexivity in a "Kekulé resonance" model](#)
- [Interrelating the three umbilic catastrophe forms: a "Grail chalice" proto-model](#)
- [Mnemonic significance](#)
- [Explanatory frameworks](#)
- [Symbolism](#)
- [Toward a new typology of dialogue -- based on the "Grail chalice" proto-model](#)

Conclusion

The pattern of relationship between the WH-questions suggests that the essence of human identity may be fruitfully understood as a play on a pattern of questions. These may be variously interrelated or nested within one another -- just as the fold catastrophe is a generic version of the others. In the light of understandings of the set of *chakras* and their relationships, these too (as psycho-energetic functions) may each be understood as individually associated with WH-questions and "catastrophes" (whether as crises or opportunities). Energetically the human body may therefore be understood as an implicit set of questions -- perhaps to be played like a flute, such as by "opening" and "closing" the *chakras*.

From a larger perspective, and in relation to any "transcendent" awareness of a harmonious [cosmic plenum](#), the catastrophes associated with particular types of question may also be understood as "mistakes" -- as discontinuities to be regretted. From a Taoist perspective, the need to answer a question may already imply that a mistake is being made.

The first four catastrophes, and the associated WH-questions, are reasonably comprehensible precisely because they deal with tangibles. The other three, the umbilics, are a fundamental challenge to comprehension because of their degree of multidimensionality. However it would appear that, through the potentially associated questions regarding existential intangibles, they do offer pointers to lines of exploration.

In conclusion, it might be said that explorations such as the above, point to the value of Thom's emphasis on more general qualitative and philosophical concerns than those with which mathematicians are conventionally preoccupied. Mathematics can do much to order the relationship between the questions that humans face -- individually and collectively -- in responding to the challenges of life in the 21st century.

References

- Vladimir I. Arnol'd. Catastrophe Theory. Springer Verlag, 1998 [[contents](#)]
- Vladimir I. Arnol'd, V S Afrajmovich and Y S Ilyashenko. Bifurcation Theory and Catastrophe Theory. Springer Verlag, 1999 [[contents](#)]
- Nuel D. Belnap Jr. and Thomas B. Steel Jr. The Logic of Questions and Answers. New Haven, Yale University Press, 1976
- M. V. Berry. Catastrophe Optics. [[poster](#)]
- Enrique Bernádez. On the Study of Language with the Tools of Catastrophe Theory. *Atlantis*, XVII, 1-2, 1995, pp. 261-291 [[text](#)]
- Sylvain Bromberger. Why-questions. In: On What we Know We Don't Know: explanation, theory, linguistics, and how questions shape them. Chicago/ London/ Stanford, (1966) 1992 [[text](#)]
- C. S. Carver. Dynamical social psychology: chaos and catastrophe for all. *Psychological Inquiry*, 8, 1997, 110-119
- Peter T. Coleman, Robin Vallacher, Andrzej Nowak and Lan Bue Ngoc. Intractable Conflict as an Attractor: presenting a dynamical model of conflict, escalation, and intractability [[text](#)]
- Leslie L. Downing:
- A Catastrophe Theory Model of Ideological Conversion and Commitment. In: Theories of the Apocalyptic, 2003
 - A Cusp Catastrophe Model of Cult Conversions. In: D.O. O'Leary and G.S. McGhee (Eds.). War in Heaven, Heaven on Earth: Theories of the Apocalyptic, Equinox. pp. 221-235.
- Daniel M. Dubois and Philippe Sabatier. For a Naturalist Approach to Anticipation: from catastrophe theory to hyperincursive modelling. *International Journal of Computing Anticipatory Systems*, 1999, vol. 4, pp. 35-59.
- Urs Egli and Hubert Schleichert. Bibliography of the Theory of Questions and Answers. In: Nuel D. Belnap Jr. and Thomas B. Steel Jr., The Logic of Questions and Answers, Yale University Press, 1976
- L. R. B. Elton and P. Cryer. Catastrophe Theory: a unified model for educational change. *Studies in Higher Education*, 1990, 15, pp. 75-86.
- Philippe Faure and Henri Korn. Is there chaos in the brain? Concepts of nonlinear dynamics and methods of investigation. *Comptes Rendus de l'Académie des Sciences - Series III - Sciences de la Vie*, 24, 324, 9, September 2001, pp. 773-793 [[abstract](#)]
- R. Fisher. Towards a social philosophy of mathematics: deliberations in the spirit of constructive realism. In Dijkum C. van, Zeeuw G. de (Eds.), Methodological explorations in Constructive Realism, Amsterdam, 1996.
- Brian R. Flay. Catastrophe Theory in Social Psychology: some applications to attitudes and social behavior. *Behavioral Science*, 23, 1978 [[text](#)]
- Nancy Frankenberry. The Empirical Dimension of Religious Experience. *Process Studies*, 8, 4, 1978, pp. 259-276 [[text](#)]
- James W. Garrison and C. J. B. Macmillan. The Erotetic Logic of Problem Solving Inquiry. 1988 [[text](#)]
- Felix Geyer. The Increasing Convergence of Social Science and Cybernetics. 10th International Congress of Cybernetics and Systems Bucharest, 1996 [[text](#)]
- Jeroen Groenendijk and Martin Stokhof:

- Studies on the Semantics of Questions and the Pragmatics of Answers. Dissertation, Amsterdam, 1984
- Questions. In: J. van Benthem and A. ter Meulen (eds), *Handbook of Logic and Language*, Elsevier/MIT Press, 1997, pp. 1055-1124 [[text](#)]

Stephen J. Guastello:

- Nonlinear Dynamics in Psychology. *Discrete Dynamics in Nature and Society*, Vol. 6, 2001, pp. 11-29 [[text](#)]
- Nonlinear dynamics in organizations. In: F.M. Guindani and E Salvatore (Ed.). *Chaos, Fractals, and Models* Pavia: Italian University Press, 1998, pp. 107-119.
- Science Evolves: An Introduction to Nonlinear Dynamics, Psychology, and Life Sciences. *Nonlinear Dynamics, Psychology, and Life Sciences*, Vol. 1, No. 1, 1997 [[text](#)]
- Chaos and organizational development. In: M. Pigazzini and P. Terni (Eds.). *Per una nuova visione de sapere: Nuove frontiere delle scienza*. Lecco: Giornale di Lecco, 1997, pp. 49-57
- Catastrophe models for workforce dynamics. In: V. Budanov and I. N. Trofimova (Eds.), *Synergetic psychology* Moscow: Moscow State Social University, 1997 (pp. 277-289). (In Russian).
- Chaos, Catastrophe, and Human Affairs: applications of nonlinear dynamics to work, organizations, and social evolution. Mahwah, NJ: Lawrence Erlbaum, 1995 [[contents](#)]

S. J. Guastello, E. A. Johnson and M L Rieke. Nonlinear dynamics of motivational flow. *Nonlinear Dynamics, Psychology, and Life Sciences*, 3, 1999, 259-274.

Charles Hampden-Turner. The Cusp of Catastrophe: Rene Thom, Christopher Zeeman and Denis Postle. In: *Maps of the Mind*, Collier Books, 1981 [[text](#)]

Jaakko Hintikka and I. Halonen. Semantics and pragmatics for why-questions. *The Journal of Philosophy*, vol. XCII, No 12, 1995, pp. 636 - 657

H. M. Hubey. Catastrophe Theory and Human Sexual Response, presented at the Third International Symposium on Systems Research, Informatics, and Cybernetics, Baden-Baden, Germany, 1991 [[text](#)]

Anthony Judge:

- Psycho-social Significance of the Mandelbrot Set: a sustainable boundary between chaos and order, 2005 [[text](#)]
- Functional Complementarity of Higher Order Questions: psycho-social sustainability modelled by coordinated movement, 2004 [[text](#)]
- Engaging with Questions of Higher Order: cognitive vigilance required for higher degrees of twistedness, 2004 [[text](#)]
- Twistedness in Psycho-social Systems: challenge to logic, morality, leadership and personal development, 2004 [[text](#)]
- DNA Supercoiling as a Pattern for Understanding Psycho-social Twistedness, 2004 [[text](#)]
- Enhancing the Quality of Knowing through Integration of East-West metaphors, 2000 [[text](#)]
- Human Values as Strange Attractors: coevolution of classes of governance principles, 1993 [[text](#)]

G. A. Kelly. A mathematical approach to psychology. In: B Maher (Ed). *Clinical Psychology and Personality: the selected papers of George Kelly*. pp.94-113. Wiley, 1969

Scott A. Kleiner. Erotetic Logic and the Structure of Scientific Revolution. *British Journal Philosophy of Science*. 1970, 21, pp. 149-165 [[text](#)]

K. H. Knuth. What is a question? In: C. Williams (Ed.), *Bayesian Inference and Maximum Entropy Methods in Science and Engineering, Moscow ID 2002*, AIP Conference Proceedings 659, American Institute of Physics, Melville NY,2002, pp. 227-242

Tadeusz Kubinski. *An Outline Of the Logical Theory of Questions*. Akademie-Verlag, 1980

A. Kuijper and L. M. J. Florack. The Application of Catastrophe Theory to Image Analysis. *Image and Vision Computing*, 2001 [[text](#)]

Henrik Lagerlund. Conformality (Mental Representation in Medieval Philosophy). *Stanford Encyclopedia of Philosophy*, 2004 [[text](#)]

L. P. Lee. The Nomenclature and Classification of Map projections. *Empire Survey Review*, 51, 7, January 1944, pp. 190 - 200 [[text](#)]

C. Y. Liou and W. P. Tai. Conformality in the self-organization network. *Artificial Intelligence*, vol. 116, 2000, pp. 265-286 [[text](#)]

C. Loehle. Catastrophe theory in ecology: a critical review and an example of the butterfly catastrophe. *Ecological Modelling* 49, 1989, pp 125-152.

Yannick Lung. Complexity and spatial dynamics modelling -- from catastrophe theory to self-organizing process: a review of the literature. *The Annals of Regional Science*, 22, 2, July 1988, pp. 81 - 111

J. R. Mackay. Conformality: Mathematical and visual. *Professional Geographer* 5: 1958, 12-13.

Frederick Mann. Unreality Imperative: the most fundamental human problem. 2002 [[text](#)]

Daniel R. Montello. Cognitive Map-Design Research in the Twentieth Century: Theoretical and Empirical Approaches. *Cartography and Geographic Information Science*, Vol. 29, No. 3, 2002, pp. 283-304 [[text](#)]

C. A. Mullen and S. Finley (Eds.). Arts-Based Approaches to Qualitative Inquiry. *Qualitative Inquiry*, 9, 2003, 2, pp. 165-329.

F. David Peat. Non-Linear Dynamics (Chaos Theory) and its Implications for Policy Planning [[text](#)]

- Denis Postle. Catastrophe Theory: predict and avoid personal disasters. Fontana, 1980
- Timothy Poston and Ian Stewart. Catastrophe Theory and its Applications. Pitman Publishers, 1978
- Mary Prior and Arthur Prior. Erotetic Logic. *Philosophical Review*, 64, 1955, pp. 43-59
- Ole Elstrup Rasmussen. The Discontinuity of Human Existence (The General and the Specific Theories of Discontinuity, Part II) *Cognitive Science Research*, 51, 1994, Lund University [[text](#)] .
- J. Barkley Rosser, Jr. From Catastrophe to Chaos: a general theory of economic discontinuities. Dordrecht, Kluwer Academic Publishers, 1991/2000 (Ch. 2: *The Mathematics of Discontinuity*).
- David Sandborg. Mathematical Explanation and the Theory of Why-Questions. *The British Journal for the Philosophy of Science*, 1998, 49(4), pp. 603-624 [[text](#)]
- Philip A. Schrodt. Patterns, Rules and Learning: computational models of international behavior, 2004 [[text](#)]
- R. Scollon. Cross-cultural learning and other catastrophes. In: Kramsch, C (Ed): Language Acquisition and Language Socialization: Ecological Perspectives, 2002
- Mildred L. G. Shaw and Brian R Gaines. Kelly's "Geometry of Psychological Space" and its Significance for Cognitive Modeling. *The New Psychologist*, 23-31, October, 1992 [[text](#)]
- Steven M. Seitz . The Space of All Stereo Images, 2001 [[text](#)]
- M. Sintonen. In search of explanations: From why-questions to Shakespearean questions. *Philosophica* 51, 1993, pp. 55 - 81;
- I. N. Stewart and P. L. Peregoy. Catastrophe Theory Modelling in Psychology, *Psychological Bulletin*, 94(2), 1983, pp. 336-362.
- Dimitrios Stamovlasis. The Nonlinear Dynamical Hypothesis in Science Education Problem Solving: A Catastrophe Theory Approach. *Nonlinear Dynamics, Psychology, and Life Sciences*, Vol. 10, Iss. 1, January, 2006, pp. 37-70 [[abstract](#)]
- A. Tesser and J. Achee. Aggression, love, conformity and other social psychological catastrophes. In: R. Vallacher and A. Nowak (Eds.) *Dynamical Systems in Social Psychology*. San Diego: Academic Press, 1994, pp. 95-109.
- Rene Thom:
- Esquisse d'une Sémiophysique: physique aristotélicienne et théorie des catastrophes. Interéditions, 1988.
 - Apologie du Logos. Hachette, 1990, 664p.
- Pavel Tichy. Questions, Answers, and Logic. *American Philosophical Quarterly*, 15, 1978, pp. 275-84
- Waldo R. Tobler. The Geometry of Mental Maps. In: R. Golledge and G. Ruston, eds. *Spatial Choice and Spatial Behavior*, Ohio State University Press, 1976, pp 69-81 [[text](#)]
- W Tschacher and J-P Dauwalder (Eds.). *Dynamics, Synergetics, Autonomous Agents: Nonlinear Systems Approaches to Cognitive Psychology and Cognitive Science*. World Scientific Publishing, 1999. (Studies of Nonlinear Phenomena in Life Science - Vol. 8) [[abstract](#)]
- Hans L. J. van der Maas. Catastrophe analysis of stage-wise cognitive development: Model, method and applications. Doctoral dissertation, University of Amsterdam, 1993.
- Hans L. J. van der Maas, Rogier Kolstein and Joop van der Pligt. Sudden Transitions in Attitudes. *Sociological Methods and Research*, Vol. 32, 2003, No. 2, 125-152 [[abstract](#)]
- Hans L. J. van der Maas and P. Molenaar:
- A catastrophe-theoretical approach to cognitive development. *Psychological Review*, 99, 1992, 395-417
 - Catastrophe analysis of discontinuous development. In: A. von Eye and C. C. Clogg (Eds), *Categorical variables in developmental research: Methods of analysis*. Academic Press, 1996, pp. 77-105
- John Archibald Wheeler and Wojciech H. Zurek. Law Without Order. In: *Quantum Theory and Measurement*. Princeton University Press, 1983, pp. 182-213
- Dominic Widdows. *Geometry and Meaning*. University of Chicago Press, 2005 [[contents](#)]
- Wolfgang Wildgen:
- Catastrophe theoretical models in semantics. In: *Internationales Handbuch der quantitativen Linguistik*. Berlin: de Gruyter, 2004.
 - Catastrophe theory as a basic tool in theoretical linguistics. *Theoretical Linguistics* 14, 1989, pp. 259-294.
 - Portée et limites de l'application de la théorie des catastrophes en linguistique. In: Petitot, Jean (Ed.), *Logos et théorie des catastrophes: a partir de l'oeuvre de Rene Thom*. Geneva: Editions Patino, 1988, pp. 410-428
 - Gestalt semantics on the basis of catastrophe theory. In: Borbé, T. (Ed.), *Semiotics unfolding*, Mouton, 1984, vol. 1., pp. 421-427.
 - Catastrophe Theoretic Semantics: an elaboration and application of Rene Thom's theory. Benjamins, 1982.
- Andrzej Wisniewski:
- Erotetic Logic and Explanation by Abnormic Hypotheses. *Paideia* (Twentieth World Congress of Philosophy, Boston, 1998)

[[text](#)]

- The Posing of Questions: Logical Foundations of Erotetic Inferences. Dordrecht, Kluwer, 1995.

Alexander Woodcock and Monte Davis. Catastrophe Theory. Penguin, 1976

Arthur Young. The Geometry of Meaning. Delacort Press / Seymour Lawrence, 1976

Ricardo Zalaya and Javier Barrallo. Classification of Mathematical Sculpture, 2004 [[text](#)]

E. C. Zeeman. Catastrophe theory: Selected papers, 1972-1977. Addison-Wesley, Reading, MA, 1977

Paul Ziolo. Ongoing Developments and Applications in Catastrophe Theory Semantics. Paper for 2nd International Nonlinear Science Conference Heraklion, Crete, 2006.



This work is licensed under a [Creative Commons Attribution-NonCommercial 4.0 International License](#).

For further updates on this site, [subscribe here](#)