4 October 2021 | Draft

Integrating Ouroboros and Yi Jing as Fundamental Symbols in 3D

Dynamics of change indicated in virtual reality by a torus of 64 hexagrams

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Introduction

Curiously the imaginative anticipation of the organization of a possible future by different cultures involves a change of metaphor from "global" to "toroidal", as discussed separately (*Imagining Toroidal Life as a Sustainable Alternative: from globalization to toroidization or back to flatland?* 2019). Indications are evident in a degree of comparability of symbols variously deemed and valued as fundamental:

- widespread continuing appreciation of circlets of prayer beads in practice, with the related circlets in some culture of so-called "worry beads" or *komboloi* (*Designing Cultural Rosaries and Meaning Malas to Sustain Associations within the Pattern that Connects*, 2000)

- the Ouroboros as tail-eating dragon or serpent, originating in ancient Egyptian iconography, was adopted as a symbol in Gnosticism and Hermeticism, and most notably by alchemy; now variously adapted for use in illustration of cosmological principles (Nancy Ellen Abrams and Joel R. Primack, *The New Universe and the Human Future: how a shared cosmology could transform the world*, 2011; Bernard Carr, *Can an Extended Science Bridge the Worlds of Matter, Mind and Spirit? Paradigm Explorer*, 2021, #136; video, *YouTube*, 26 August 2021)

- the the Hindu-Buddhist symbol of Indra's Net, explored mathematically as Indra's Necklace (David Mumford, et al. *Indra's Pearls: the vision of Felix Klein*, 2002)

- the Shao Yung circle of *Yi Jing* hexagrams as communicated to Gottfried Leibniz (1703), and recognized as of seminal significance in his reflections on the binary coding from which modern computer operations have developed (*Envisaging a Comprehensible Global Brain -- as a Playful Organ*, 2019). The set of hexagrams is widely known to the West as the *I Ching: the Book of Changes* (1950).

- the circular configuration of symbols of the Zodiac, basic to widespread engagement with astrology; adapted as a "Rosetta stone of meaning" to indicate principles of control and navigation of a vehicle from an engineering perspective -- extending to include insights of sociophysics (Arthur Young, *Geometry of Meaning*, 1976), as discussed separately (*Criteria for a Rosetta stone as a meta-model?*; *Geometry of meaning and cognitive embodiment?*, 2016).

Especially curious in terms of comparability of the disparate models above is the ongoing major international investment in the innovative toroidal design of the International Thermonuclear Experimental Reactor (ITER). This invites speculation on the psychosocial implications of its design challenges (*Enactivating a Cognitive Fusion Reactor: Imaginal Transformation of Energy Resourcing (ITER-8)*, 2006).

Together these suggest the possibility of a design challenge, namely one of exploring designs which might honour their respective

insights in order to frame in dynamic terms a new kind of strategic architecture -- if only of mnemonic significance, as argued separately (*Time for Provocative Mnemonic Aids to Systemic Connectivity?* 2018; *Global Challenge of the Global Challenge: ¿ In-quest of a decision-making framework appropriate to a world in crisis ?* 2016).

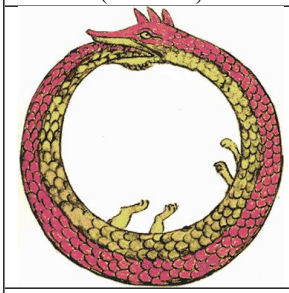
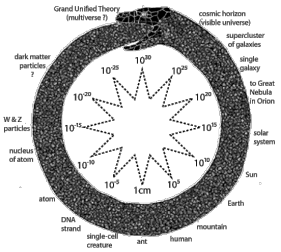
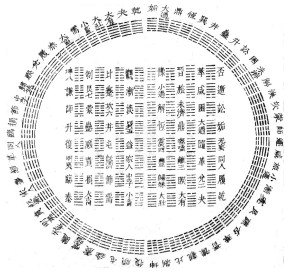
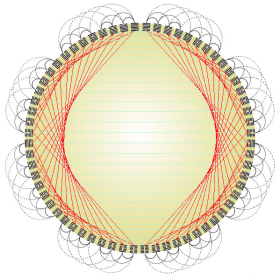
The specific focus in what follows is however on "integrating" in virtual reality the Ouroboros with the *Yi Jing* circle as an approach to reframing design consideration for the other toroidal configurations indicated above, together with others indicated below. This endeavour has the further merit of interrelating symbols more typically associated with West and East respectively (*Enhancing the Quality of Knowing through Integration of East-West metaphors*, 2000).

The fundamental question addressed by this exercise is how virtual reality can be used to "hold" and explore a greater degree of complexity of diverse cultural significance -- more comprehensibly and in a manner more readily susceptible to communication. It follows from previous efforts to present symbols of importance with which fundamental values are variously associated (*Eliciting Insight from Mandala-style Logos in 3D: interactive engagement with mandalas and yantras in virtual reality*, 2020; *Cognitive Implications in 3D of Triadic Symbols Valued in 2D*, 2017; *Reconciling Symbols of Islam, Judaism and Christianity*, 2017).

A further objective of this presentation is to make readily available the code by which the interactive virtual reality animations are generated in order to enable others to experiment in a "hands-on" mode with more meaningful design alternatives. As explained here, this is possible because the program code for the animations can be readily altered with any text editor. The result can be viewed with a virtual reality viewer -- of which some are indeed freely available.

Previous 3D experiments with representations of symbols in 2D

Representations in 2D of Ouroboros and *Yi Jing* circle:

Ouroboros (traditional)	Ouroboros (physical adaptation)	Hexagram circle (Shao Yung, 1703)	Hexagram circle (redrawn with changes)
			
Reproduced from *Wikipedia*	Adapted from Abrams and Primack (2007)	Perkins, Franklin. *Leibniz and China: a commerce of light*. Cambridge UP, 2004. 117., Public Domain, Link	

One modern version of the Ouroboros, as presented above, offers a means of understanding the scale of physical objects. It is adapted from that of Nancy Ellen Abrams and Joel R. Primack (*The View From the Center of the Universe: discovering our extraordinary place in the cosmos*, 2007). Other variants have been presented (Robert P. Munafo, *Size Scales of the Universe at Home*; Cary Huang, *The Scale of the Universe: Planck length up to the entire universe -- interactive visualisation*). Most recently, another has been presented by the mathematican and cosmologist, Bernard Carr (*Can an Extended Science Bridge the Worlds of Matter, Mind and Spirit? Paradigm Explorer*, 2021, #136; video, *YouTube*, 26 August 2021).

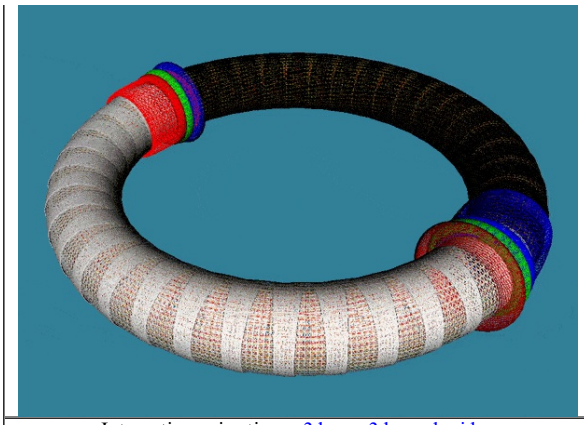
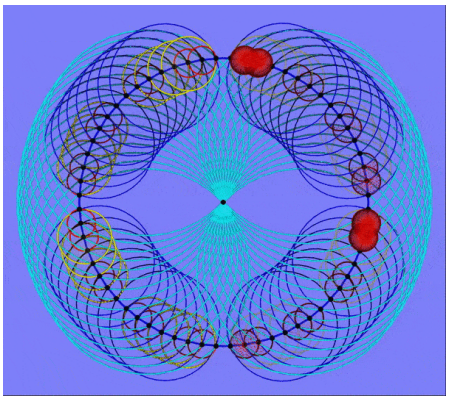
An extensive discussion of the wider signifiance of the Ouroboros is offered separately, including experimental animations in virtual reality:

- *Complementary visual patterns: Ouroboros, Möbius strip, Klein bottle* (2017)
- *Circular configuration of cognitive phases framing toroidal experience?* (2017)
- *Transcending both scientific and poetic comprehension of multiverse* (2012)
- *Explanation vs. Inplanation: multiversal embodiment through the Ouroboros* (2012)

The Shao Yung circle of *Yi Jing* hexagrams (above left), of significance to the seminal reflections on binary coding of Gottfried Leibniz (1703), is illustrated and discussed separately (*Envisaging a Comprehensible Global Brain -- as a Playful Organ*, 2019; *Experimental Revolutionary Animations of a Chinese Pattern of Metaphors: based on rotations of a circular configuration of I Ching hexagrams*, 2015)

Representations in 3D: Previous exercises have focused on the possibility of new insights to be derived from separate representation of the Ouroboros and *Yi Jing* circle in 3D (*Experimental animations in 3D of the ouroboros pattern*, 2017; *Global brain as an organ: playable, playful or neither?* 2019). The following animations derive from these.

Animations in 3D	
Schematic Ourobouros animation in 3D	Animation of schematic hexagram circle in 3D

	
Interactive animation: :x3dom; x3d; vrml; video	x3dom

The pattern of hexagram relationships (above right), derived from the original Shao Yung circle, offers a useful template to explore animation in 3D. As a template it can be reframed as a form of instrument for visual effects to which sound effects could be added -- then constituting a form of musical instrument, if not an organ or a harp.

The pattern recalls the two hemispheres of the human brain. The division into 8 groups (yellow) of 8 circles (red), is potentially clustered into 4 groups of large circles (blue). Each such 2D circle can be represented as a sphere -- evident through rotation of the whole. That approach could have been extended to render the circle as a whole into a global form.

Each sphere is rendered relatively visible or transparent in the dynamic of the animation. This effect could have been articulated further to distinguish the 64 red spheres individually, for example.

The result is aesthetically crude and merely intended as an indication of how the animation could be "composed" or "played" -- a proof of concept. Understood in cognitive terms, the 4 blue spheres are indicative of the common 4-fold distinction of modalities. Similarly the 8 yellow spheres recalls the 8-fold distinction of modalities -- a variant of the 8-fold way. The 64 red spheres recall the decision-making distinctions made in the pattern of the *I Ching*.

The spheres can be understood as cognitive "worlds" within which people may primarily function, whether the red-level only, extending to the yellow level, or the blue level -- each such level bridging a greater range of modalities. A pattern of "worlds within worlds" consistent with intuitive reference to the "music of the spheres"

Understood in mechnical terms, the animation recalls the function of a combustion engine -- whether 4-cylinder, 8-cylinder, or more. The dynamics are then suggestive of the pattern in which the cyinders "fire" -- especially if greater attention was given to the rhythm. If the circles were rotated, rather than represented as spheres, this would give the effect of fans rendering the pattern "flight enabled" as with the operation of some drones.

As an alternative, each circle could be transformed into a torus rather than a sphere suggesting pathways through which the distinctive "cognitive worlds" travel (*Imagining Toroidal Life as a Sustainable Alternative: from globalization to toroidization or back to flatland?* 2019).

Alternative hexagram representation -- as a resonance hybrid?

Hexagram as Star of David: The conventional representation of the *Yi Jing* hexagrams is as a "stack" of six (un)broken lines. Of some symbolic and cognitive interest, there are other possibilities for their configuration.

Six lines are configured in a number of cultures to form a double triangular "hexagram". This is most commonly associated in the West with the Hebrew Star of David symbol. It is however also used by Christians (notably the Mormons) and in Islam. Six pointed stars are also to be found in the cosmological diagrams of Hinduism, Buddhism, and Jainism. The non-Jewish Kabbalah (also called Christian or Hermetic Kabbalah) interprets the hexagram to mean the divine union of male and female energy. In traditional alchemy, the two triangles represent the reconciliation of the opposites of fire and water.

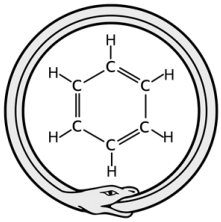
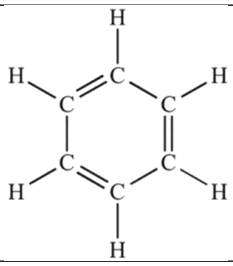
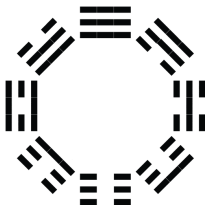
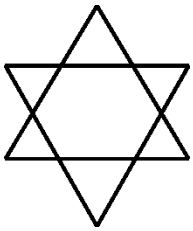
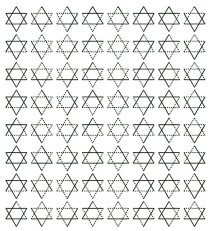
In the earlier exploration noted above (*Sustainability through Magically Dancing Patterns 8x8, 9x9, 19x19 -- I Ching, Tao Te Ching / T'ai Hsüan Ching, Wéiqí*, 2008), using one particular triangular design convention, it is therefore also of interest to explore the configuration of the 6 lines of the *I Ching* hexagram into a double triangle consistent with such traditional symbolic use. The following table (below right) was originally presented there (*Double triangular representation of hexagrams: Star of David*)

Another alternative is to configure the hexagram lines as originally imagined, and subsequently depicted, in the benzene model (below left) -- now so fundamental to many organic molecules, and the focus of many animations (D. Meliga, L. Lavagnino and S. Z. Lavagnino, *Kekulè's Monkey in Anthracene*, *Wolfram Demonstrations Project*, 19 February 2020; Mike Thompson and Charlie Style, *Benzene*, *Molecule of the Month,* August 2011).

Hexagrams as organic molecule ("benzene-style"): The visualization exercises which follow involve a switch from a stack of *Yi Jing* hexagram lines to a configuration more akin to that currently favoured in chemistry for representations of the benzene molecule. Especially relevant is the fact that that molecule has a resonance structure associated with a shift between the bond configurations, as illustrated by the animation below.

Of some relevance to this argument, the image combining the benzene molecule with the Ouroboros (below left), as reported by August

Kekulé, is widely discussed as Kekulé's dream. **The design option for integrating *Yi Jing* hexagrams with the Ouroboros, as explored below, is based on a rotation of that depicted hexagram (into the plane of the paper) such that the set of 64 forms the "skeletal structure" of the toroidal Ouroboros in 3D.**

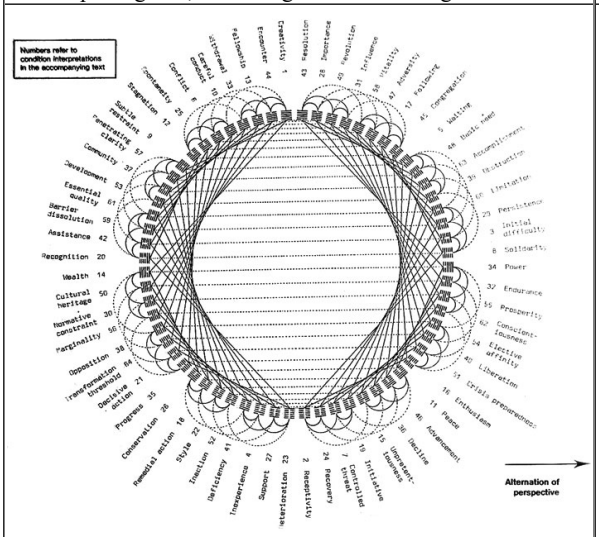
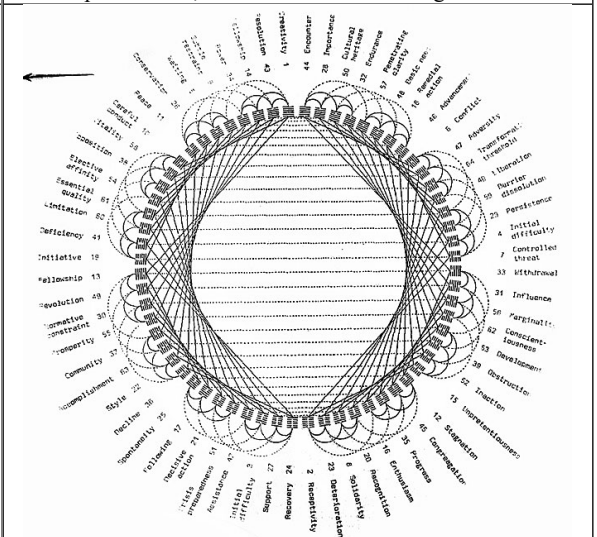
Varieties of resonance presented or implied as animations				
Benzene molecule in the Kekulé dream	Benzene as a resonance hybrid	Alternation between 2 *BaGua* arrangements of 8 trigrams	Alternation between 64 hexagrams (dynamics of triadic bonding)	64 *I Ching* hexagrams configured as double triangles (as in animation on the left)
				
Haltopub, CC BY-SA 3.0, via Wikimedia Commons				

Hexagram resonance: The depiction of the benzene molecule is then suggestive of a means of distinguishing the broken and unbroken lines of the conventional *Yi Jing* hexagrams. Visually at least, the double bond of the molecular depiction can be understood as a broken line, whilst the broken line can be associated with the single bond (although the reverse could be assumed, given the relative strength of the double bond). It is of course the case that the *Yi Jing* hexagrams exhibit a form of resonance between each other -- indicative of the pattern of changes the set of 64 hexagrams is held to embody.

Of relevance to this argument are the two "arrangements" of the 8-fold *BaGua* pattern, termed "Earlier Heaven" and "Later Heaven". These are typically displayed separately and their relationship is not readily comprehensible, although each has its own coherence. Understood as alternating between two conditions of coherence, the two can be presented in an animation (above centre).

There is a case for recognizing that each of the two *BaGua* patterns is "unstable" and has an inherent tendency to "flip" into the other pattern. This alternation can be understood as a form of "pumping" action -- even a form of "perpetual motion" in cognitive terms. It could also be recognized as constituting a form of 8-fold resonance hybrid, as is characteristic of the 6-fold benzene molecule fundamental to the organic molecules basic to life.

Orientation assumption: A further assumption is provisionally introduced in the design of the animations which follow. The "upper" trigram of a hexagram is now depicted by the three (un)broken lines on the "left" side of the vertical image (benzene-style), whereas the "lower" trigram is depicted by those on the "right". This provisional assumption could of course be variously reversed, especially since it goes to the heart of whether a hexagram is "read" from the "bottom up" or from the "top down".

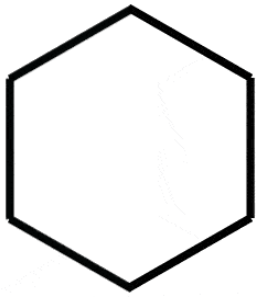
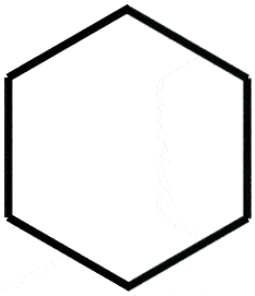
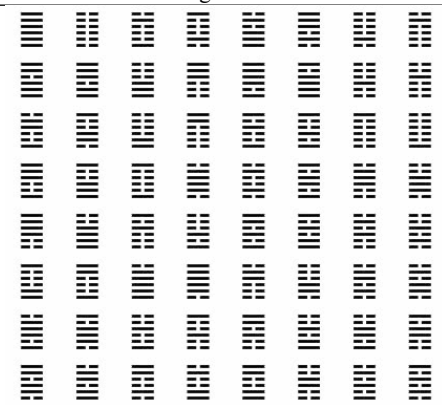
Map of transformations encoded by a circle of hexagrams and their relationships	
"Top-in": global, 'heads-together' networking conditions	"Top-out": local, 'back-to-back' networking conditions
	
Reproduced from *Alternating between Complementary Conditions* (1983)	

The sequence of hexagrams can then be represented in the following animations (below left and centre). These design choices then frame the possibility of presenting a set of 64 benzene-style hexagrams. The set can be presented as a linear sequence, respectful of the Shao Yung ordering -- or of the alternative traditional arrangements.

Tabular arrangements: The Shao Yung circle (as originally presented, and illustrated above) includes the more familiar tabular arrangement and therefore implies a reconciliation. There are however four such 8x8 traditional presentations Fu Xi; Jing Fang; King Wen; Mawangdui, as discussed separately (*Strategic Patterns in terms of Knowing, Feeling and Action*, 2008; Steve Marshall, *Yijing*

Hexagram Sequences, 2005; Yijing Dao, *Archive of Yijing scans from Chinese and other sources*, 2006).

That 8x8 patterning could be understood as a form of "periodic table" -- but with respect to intangible matters. The four traditional tabular configurations can be provocatively combined into a single animation, below right (reproduced from *Identifying the Root Cause Focus of Radical Identity: reframing the complex space of radicalisation dynamics*, 2015).

Contrasting encoding systems		
top-on-left	top-on-right	Combining Fu Xi, Jing Fang, King Wen and Mawangdui in a single animation
		

Symbol rotation as dynamic essential to engaging with value-inversion, 2017 *****

Configuring the set of hexagrams as a toroidal Ouroboros

Given the prospect of interrelating the Shao Yung circle of hexagrams and the Ouroboros, of greater interest is the possiblity of curving a linear set of hexagrams into a circle. The benzene-style configurations then become indicative of the annular segments of a toroidal Ouroboros in 3D

Articulating the length of the Ouroboros: Since each hexagram is traditionally associated with a distinctive connotation (expressed metaphorically), this has the particular advantage of articulating cognitively the structure of the Ouroboros into 64 segments. Of even further interest, using the interactive facilities of virtual reality displays, it is then possible to traverse the toroidal pathway of the Ouroboros "from within" -- a toroidal tunnel through which it is then possible to move.

Distinctive imagery: Indicative text is traditionally associated with each hexagram. In the toroidal form this can be presented as a sequence of images through which it is possible to move interactively around the torus. One possibility for the image is the traditional Chinese idiogram associated with each. Another is an indication of the associated metaphor from any common English translation, for example.

Connectivity: It is of course the case that the Shao Yung circular pattern in 2D implies transformations ("changes") between the hexagrams, whether to neighbouring "conditions" or to those more distant -- including those across the circle. These result from a broken line in a hexagram switching to an unbroken line, or the reverse. This has potential implications for interpretation of the detailed significance of the Ouroboros -- typically absent from its interpretation as a symbol.

Meaningful design options: As a construct in virtual reality, the resulting design offers many ways of transforming the visual representation of the torus and its components (using a simple text editor). These can include contrasting use of colour, rates of movement, radius of hexagram lines, and configuration assumptions ("top-in" versus "top out") -- possibly rendered interactive. Of some interest is exploration of contrasting sizes of hexagrams, or the extension of the lines, effectively as "limbs" or "antenna".

It is the "top-out" ordering (above left in 2D) which is used in the 3D visualizations below, in contrast with the possible "bottom-out" alternative (above right). Interactively it could be made possible to switch between them

Exploratory movements: It is also possible to consider animating the distinctive movement of individual hexagrams. Each can for example be rotated to offer a circular "gallery-style" display of any associated images -- to be viewed from the centre -- but thereby losing the capacity to traverse the toroidal tunnel.

The size of the hexagrams might be increased or decreased in phases along the torus to reflect a form of peristalsis -- on the assumption that the Orobouros has some analogue to swallowing and movement along its body.

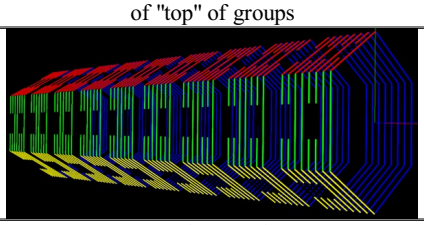
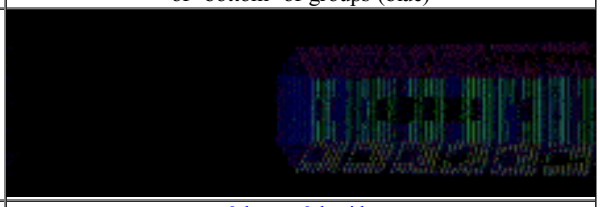
Experimental interactive animations of the Ouroboros-Yi Jing "integration"

In the traditional Shao Yung circle the hexagrams are in groups of 8 around the circle. In each group, the inner or lower trigram is common to all hexagrams in each group. The outer or upper trigrams are of 8 types within each group. In the presentations below, the lower trigrams (in blue) are necessarily identical for each group -- and the pattern may be readily recognized in the animation on the right. For the upper trigram, the colour convention is an upper line in red, a middle line in green, and a lower line in yellow. The pattern for each group is the same as can be seen from the image on the right.

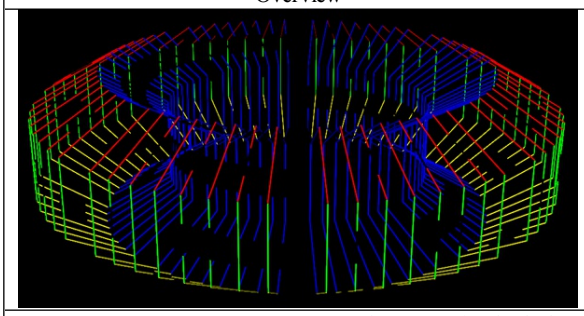
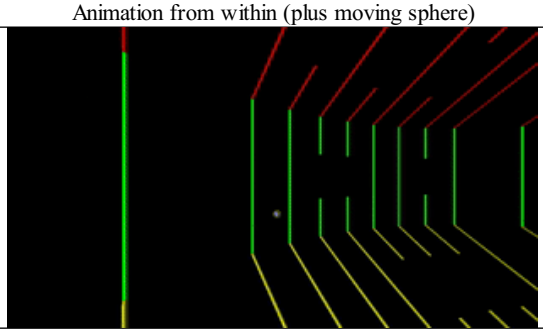
The ability to interact with the following virtual reality animations via web browsers is necessarily constrained, as discussed below (*Technical constraints of 3D applications and their cognitive implications*). The remarks apply primarily to those presented as GIF

animations or offering access to videos (MP4). This follows an indication of possibilities for users to experiment with the original models using a text editor (*Indications of how to experiment with the 3D animations*).

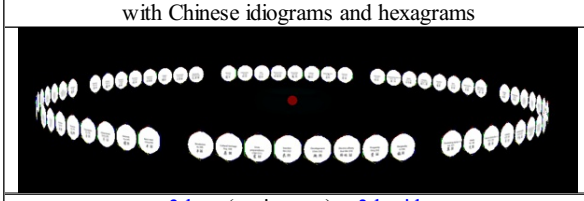
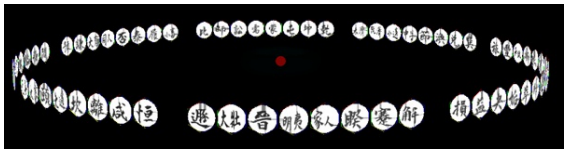
Some of the animations indicate the possibility of interactive access via a web page within which the animations is embedded using the X3DOM protocol -- thereby offering a good approximation to the interactivity associared with the original model. Unfortunately (at the time of writing) the X3DOM facility seems to be constrained in its ability to display the images which are an obvious feature of many of the animations which follow. Nevertheless it offers a feel for the interactivity and a sense of the possibilities of cognitive engagement with such arrays.

Presentation of 64 Yi Jing hexagrams in a cylindrical array of groups of 8	
Showing common coloured patterning of "top" of groups	Rotation of image on left showing common patterning of "bottom" of groups (blue)
	
x3dom, x3d	x3dom, x3d, video

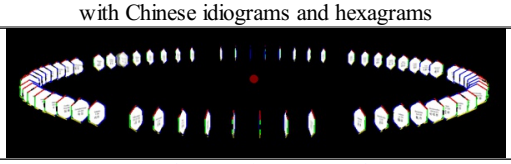
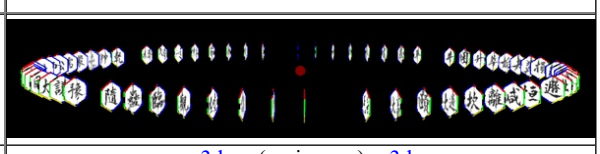
The cylindrical array of hexagrams can be curved to form a torus, assuming the lower trigrams are indeed to be positioned within -- following the pattern in the Shao Yung circle -- with the upper trigrams on the outer side of the torus ring.

Toroidal Ouroboros form achieved by curving the linear stack of hexagrams above	
Overview	Animation from within (plus moving sphere)
	
x3dom (offering both the above as different viewpoints)	

Each hexagram is traditionally associated with a Chinese idiogram, a 6-line code, and a brief text of metaphorical significance. These can be variously associated with the individual hexagrams in the images above, as shown below. In this case the separation between the hexagrams is necessarily greater than in the version above -- to enable the images to be viewed.

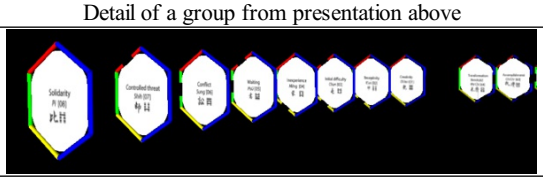
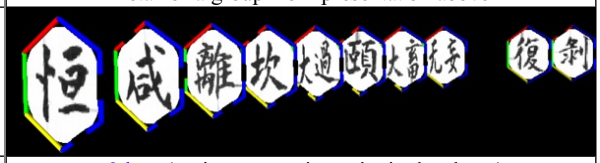
Overview of gallery-style presentation of 64 hexagrams with distinctive imagery	
Hexagrams carrying English indications with Chinese idiograms and hexagrams	Hexagrams carrying traditional Chinese idiograms
	
x3dom (no images); x3d; video	x3dom (no images); x3d; video

In the presentation below, the orientation of the hexagrams is switched from gallery-style to emphasize the toroidal Ouroboros-style.

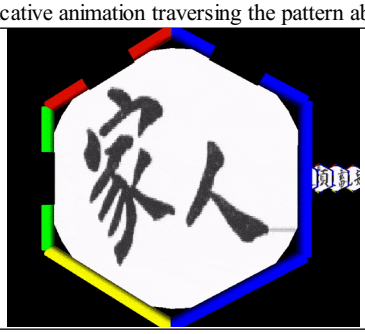
Overview of Ouroboros-style presentation of 64 hexagrams with distinctive imagery	
Hexagrams carrying English indications with Chinese idiograms and hexagrams	Hexagrams carrying traditional Chinese idiograms
	
x3dom (no images); x3d	x3dom (no images); x3d

Virtual reality viewers can enable users to switch perspectives -- known as "**viewpoints**" -- within the same model. The images below offer a closer perspective on a group of hexagrams in the animations above. Cycling through the viewpoints is typically achieved using the PgUp/PgDn keys.

Viewing the illustrations of a group of 8 hexagrams from the animations above	

Detail of a group from presentation above	Detail of a group from presentation above
	
x3dom (no images, a viewpoint in the above)	x3dom (no images, a viewpoint in the above)

Another perspective is possible from within the toroidal Ouroboros, through animations exposing the viewer to a succession of images in the animations below. Ideally these would be enabled in the X3DOM presentations above (currently constrained by a technical bug)

Animations of a selection of images from within the torus	
Indicative animation traversing the pattern above	Indicative animation traversing the pattern above
	
video	video

Rendering the images associated with all 64 hexagrams accessible in the virtual reality models above, results in a web page which is relatively slow to load -- other than via the X3DOM facility. For convenience, the sequence is presented in the following simpler GIF animations. Clearly a different rate could be chosen for the animation.

Animations of the complete sequence of images from within the torus	
Cycle with English metaphor (plus)	Cycle with Chinese idiogram alone
	

It should be emphasized that modifying the virtual reality models enables the rate of movement within the animations above to be decreased or increased -- according to preference. Some appreciation of this is possible by altering the rate of display of the indicated videos, namely the playback speed. The direction of movement can also be changed -- switching from a 1-to-64 sequence to a 64-to-1 sequence.

Cognitive engagement with fundamental symbol dynamics

The fundamental question addressed by this exercise is how virtual reality can be used to "hold" and explore greater complexity of diverse cultural significance -- more comprehensibly and in a manner more readily susceptible to communication.

Crowns and circlets: Some of the perspectives offered by the animations above recall the symbolic importance of a crown and the cognitive implications suggested by wearing one, as discussed separately (*Engaging with Globality through Cognitive Crowns -- 3rd Dimension: All-encompassing, well-rounded experience*, 2009). This develops the argument of a Dimension 1 relating primarily to the cognitive significance of the circlet. With respect to a crown, the focus is on the potentially more cognitively significant implications of the crown -- as a developed version of the circlet or a combination of such devices. It might be described as the challenge of achieving "cognitive traction" in governance.

Together these parts focus on the challenge of providing succinct integrative vehicles for significance, notably as this relates to any existential sense of identity. The focus in the Dimension 1 and Dimension 2 arguments is on the challenge more conventionally understood in terms of the knowledge management required by governance and the governors -- on behalf of the governed. Separately in a Dimension 4 presentation the inadequacies and impracticalities of such possibilities, hitherto considered realistic, are used to reframe the cognitive challenge for any individual obliged to order cognitive skills and accessible insights -- where such dependence on external authority is now clearly unrealistic. A summary of the 4-part argument is provided separately (*Metaphorical Geometry in Quest of Globality*, 2009).

Curiously little attention is given to the distinctive pattern of precious stones of the highest value which are incorporated into the design of crowns as symbols of sovereign authority. Most obvious is the symbolism associated with the diamond -- especially evident in the

case of the diamond mind metaphor cultivated in Buddhism (*Patterning Archetypal Templates of Emergent Order: implications of diamond faceting for enlightening dialogue*, 2002; *Summary of Gemstone Faceting and Crystals*, 2002).

The reference to facets calls for recognition of the extent to which "facets" also feature in terms of faceted clssification in the organization of knowledge and as psychological facets. Such uses suggest metaphors through which the hexagrams organized in a toroial configuration can be explored as facets from all these perspectives.

Hence the importance of the highly original mathematical exploration of Indra's Necklace in one chapter of complex considerations of the Hindu-Buddhist symbol of Indra's Net (David Mumford, et al. *Indra's Pearls: the vision of Felix Klein*, 2002). In that sense, given the commentary traditionally associated with each hexagram, any such array could be recognized as an indication of values fundamental to decision making. Ironically society is much constrained in its ability to identify and indicate what are the "human values" so frequently cited in political discourse, as separately explored in the Human Values Project.

The significance of the crown metaphor is also evident in the cognitive role attributed to the crown chakra (*Sahasrara*) of Hinduism, discussed further below and separately (*Global Insight from Crown Chakra Dynamics in 3D? Strategic viability through interrelating 1,000 perspectives in virtual reality*, 2020).

Logos: It is appropriate to note the extent to which circular insignia are valued as an indications of collective identity through logos -- many of which depict symbols (*Symbolic Insignia Indicative of Global Health*, 2021).

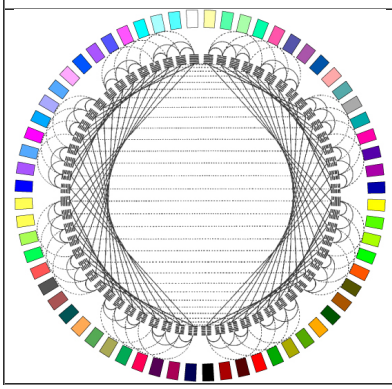
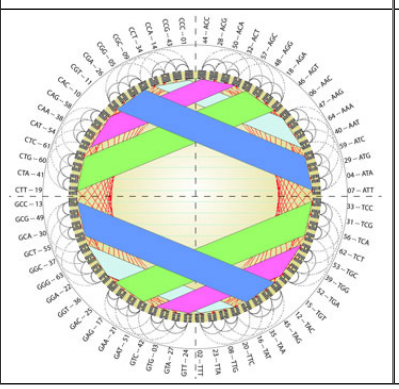
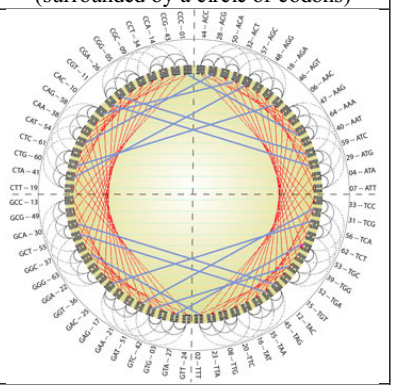
The current exercise follows from previous efforts to present symbols of importance with which fundamental values are variously associated (*Eliciting Insight from Mandala-style Logos in 3D: interactive engagement with mandalas and yantras in virtual reality*, 2020; *Cognitive Implications in 3D of Triadic Symbols Valued in 2D*, 2017; *Reconciling Symbols of Islam, Judaism and Christianity*, 2017).

Cognitive implications of challenges of nuclear fusion: Especially curious in terms of comparability is the ongoing major international investment in the innovative toroidal design of the International Thermonuclear Experimental Reactor (ITER).

This invites speculation on the psychosocial implications of its design challenges (*Enactivating a Cognitive Fusion Reactor: Imaginal Transformation of Energy Resourcing (ITER-8)*, 2006). A merit of the animations above is the possibility they offer of passing through a torus currently designed to enable energy of a higher order to be generated.

Toroidal presentation of hexagrams: In the quest for coherence, the argument above suggests that the comprehensibility of tabular animations is inadequate to the challenge of the times. This frames the question as to whether dynamic patterns can be presented otherwise, as explored below (*Exercises in centro-symmetric encoding using hexagrams*, 2021). The image on the left below derived from separate discussions (*Living with Incomprehension and Uncertainty: re-cognizing the varieties of non-comprehension and misunderstanding*, *Towards the Systematic Reframing of Incomprehension through Metaphor*, *Towards the Dynamic Art of Partial Comprehension*, 2012)

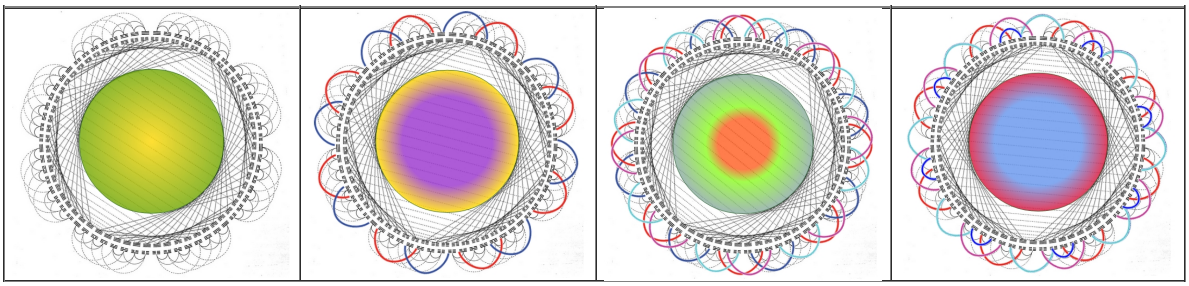
The images below (centre and right) derived from a discussion of *Changing Patterns using Transformation Pathways*, 2015) which explored "camp-us" inspiration in the context of an alien world view.

Indications of connections between hexagrams		
Experimental association of "colours" to the 64 hexagrams of the *I Ching*	Depiction of Rummer's transformations in relation to the circle of hexagrams (surrounded by a circle of codons)	Depiction of transformations based on Rummer in relation to the circle of hexagrams (surrounded by a circle of codons)
		

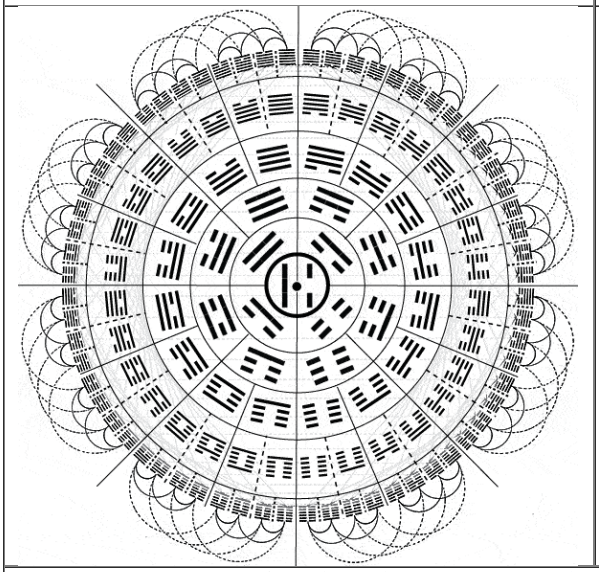
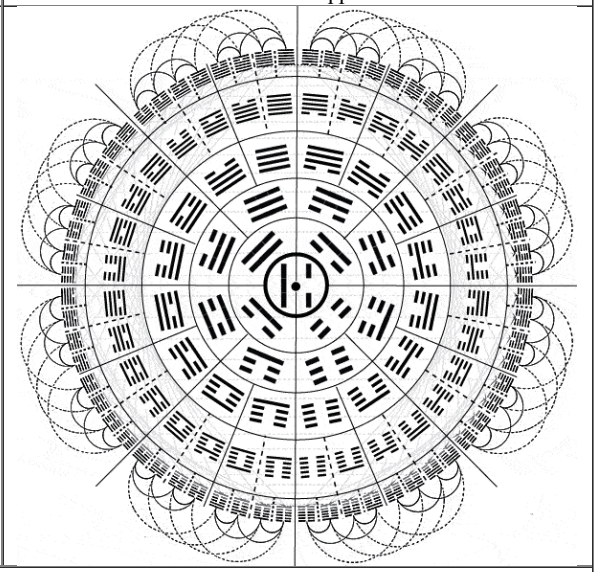
Of particular interest in the case of the images on the right is the extensive study by Anagarika Govinda (*The Inner Structure of the I Ching; the Book of Transformations*, 1981), as discussed with imagery (*Circular representation: inner structure*, 1983).

Rotation of configurations? Another approach is through rotation of the configuration, as illustrated below from an earlier exercise (*Experimental Revolutionary Animations of a Chinese Pattern of Metaphors: based on rotations of a circular configuration of I Ching hexagrams*, 2015)

Screen shots of experimental animations presented separately (in case of browser difficulties in presenting animations)			
Inner circle of trigrams rotating relative to outer circle of trigrams [animation; video]	With rotation of outer ring [slower] [faster]	With counter-rotation of 2 outer rings [slower]	With counter-rotation of 4 outer rings [faster]



Comprehension can be enhanced otherwise by variously incorporating the four distinctive perspectives above into animations. Those below offer a contrast between a clockwise rotation and one involving reflection with a contrasting perspective (vertically or horizontally). The animations reveal a degree of technical imperfection in the original, however these fortuitously give rise to small movements which enhance the sense of a living system. Advantage was also taken of a technical facility for fading between the perspectives -- offering subtle rather than abrupt transitions.

Animations between distinctive orientations of circular array of nested coding patterns	
Clockwise rotation	Reflection of opposites
	
Alternative variant at *Dynamic Exploration of Value Configurations* (2008).	

Indications of how to experiment with the 3D animations

The animations are necessarily designed to be **viewed**. Depending on browser facilities, this may be done **interactively**. experimenting with altenatives.

As noted above, the animations -- although seemingly complex -- lend themselves to exercises in further experimental modification. Most simply this can be done with any text editor -- after downloading the indicated X3D files. Although the code may at first sight appear complex and overly extensive, changes can be easily made using conventional cut-and-paste techniques -- to colour, for example. When saved as a standard X3D file, this can be viewed interactively with a virtual reality viewer such as FreeWRL -- itself freely accessible (see *X3D Resources: Applications*).

This approach offers a useful hands-on introduction to virtual reality coding -- requiring only basic skills. If mistakes are made, it is sufficient to revert to a backup of the download of the original X3D file. If the animation does not work, because some mistake has been made, checks can first be made using *X3D Validator*.

A second approach is to make use of an X3D editor with validation facilities -- if only to indicate what the errors may be. Several such editors are freely available, including *X3D-Edit* (*X3D Resources: Authoring*). These tend to require much greater awareness of X3D standards and programming techniques -- a progression far beyond the straightforward use of a simple text editor. In addition, because the animations presented here have many lines of coding, this may stretch the capacity of such software -- memory limits, etc. [*It is appropriate to note that if the animations had been produced using an X3D editor alone, more sophisticated techniques could be used to render the X3D file more compactly -- if far less comprehensible to the uninitiated.*]

A third approach is to use a software application which can generate the many lines of X3D code for the animation, based on a relatively simple program. The merit of this approach is that it enables a variety of features of the animation to be easily changed -- by simple changes to options in the program, in contrast with multiple cut-and-paste operations using a text editor. This could avoid the need to experiment with several X3D files (each modified to enable different design options in the animations).

The software application used for this purpose was *OpenInsight* -- commercially available. Given the relative simplicity of the animation source program (accessible here***), it could however be rewritten for other applications -- possibly far more efficiently. However the resulting X3D file generated might need to be validated as indicated above. The animations presented above were developed using all three approaches -- text editor, X3D editor (*X3D-Edit*), and a code generating application (*OpenInsight*).

A contrast needs to be made between the relative ease of experimenting on a local computer with X3D files and presenting the resulting animations over the web for others. There are constraints to doing so because of the variety of browsers and the standards with which they work. In principle it is possible to embed the X3D file in an HTML web page using X3DOM standards, as illustrated separately with many examples (*Eliciting Insight from Mandala-style Logos in 3D: interactive engagement with mandalas and yantras in virtual reality*, 2020). Some X3D editors allow the animation to be exported directly as an X3DOM-formatted web page. Of course it is alway possible simply to copy the X3D file to someone else to be viewed locally.

Technical constraints of 3D applications and their cognitive implications

There is a not insignificant challenge to representation of relatively complex patterns above over the web -- in contrast with enabling users to interact with one or more virtual reality models on their personal computers. In this sense any final product is unsatisfactory, as with those presented above. Greater insight is gained from experimenting interactively with design metaphors and the resulting models, especially since many adjustments can be made for personal preferences -- colours, rates of movements, relative sizes, etc.

The following constraints all have their cognitive implications in terms of the ideal of being able to share interactive models over the web.

Platforms and browsers: The process described above applies to users of PCs. It is less evident how the different approaches might be undertaken on a Mac or with other platforms. Major difficulties may be associated with browsers and their evolution. Features which previously worked, may cease to work. Those promoting the use of one or other platform or browser may be less than attentive to the presentation of X3D models

Modelling software and viewers: The 3D protocol used for the above models is X3D. This is in process of replacing the earlier WRL/VRML protocol for which earlier software and viewers are available. Editors for X3D may however enable exports into models in the earlier protocol, although some features may not work.

There are a number of applications which enable 3D models to be created and modified, whether freely or commercially avalable (*X3D Resources: Authoring*). The suggestion made above highlighted the ease with which a text editor could be used to edit an existing model -- provided errors are not introduced -- calling for validation in some form.

Size of model: To avoid making a web page too cumbersome to load, especially for those with limited (and possibly costly) connectivity, only selective representations can be presented directly. Possibilities include:

- static images, which tend to inhibit recognition of the implied dynamic and scope of a model
- videos of interaction dynamics, which ideally would be relatively lengthy where there is a complex cycle to be seen -- necessitating presentation of selections, only accessible via a separate download. Screen recording is an issue (see below)
- selective GIF animations, typically derived from a screen-recorded video, which could themselves be lengthy

Alternative options: Possibilities include:

- access to X3D model, as suggested above, for those with the skills to view them -- and possibly to modify them
- presentation of the X3D model within an X3DOM page enabling interactivity. This is clearly an ideal which is actively developed. However there may be constraints imposed by the evolving protocols which inhibit features of the model. In the case of those above, the images do not load, being subject to the security constraints imposed by the CORS protocol. Some X3D authoring applications enable export into an X3DOM page format which can be viewed through a web browser

Evolution of standards and protocols: The considerable interest in virtual reality is resulting in developments within a context in which standards and protocoles continue to evolve rapidly. This process may inhibit operation of models or require stricter adherence to standards, especially in the header records of a model -- especially any calls to other applications.

Such development raises the question of how proficient one needs to be in developing a model -- and why the straightforward operation of models is constrained in this way, potentiaally to the point of requiring assistance (if it can be found). The difficulty is compounded when different standards are required for different platforms.

Imperfections and bugs: Much time can be spent on the simplest tasks when developing a model. The approach taken towards a working model may be experimental -- with inefficiencies in coding only apparent when the model is finally operating. Models can in all probability be produced more efficiently using more sophisticated coding -- if one has the skills and the time.

Most problematic are the coding errors which prevent the opertion of the model and may require considerable patience todetect and remove, Model authoring software may be of considerable assistance, as with online validators. Virtual reality viewers may offer some indications if the model is not loading correctly. The developer tools offered by Microsoft Edge may offer other indications.

Personal skills and assistance: A distinction must necessarily be made between X3D authoring by professionals and the skills which amateurs may bring to the task. This frames the question of how skillful one needs to be to produce a meaningful virtual reality model, or -- expressed otherwise -- how ignorant can one be and still achieve a meaningful result.

Emphasis above was placed on the ease with which those with limited skills can modify existing models -- using a text editor. As with many computer-related preoccupations, there are fora in which people can request assistance from other users. It is possible to sign up for the x3d-public list and send queries there. Information on that list is available at http://web3d.org/mailman/listinfo/x3d-public_web3d.org. A separate list is available for X3DOM (x3dom-users list: https://sourceforge.net/projects/x3dom/lists/x3dom-users)

Costs (if any): Models can be made, modified and uploaded using facilities which are freely available. Costs are incurred when use is made of commercial software -- to the extent that this offers additional benefits (*X3D Resources: Authoring*).

Validation: As noted above, checks can be made using *X3D Validator*. A major issue, as with any validation, is whether any messages are to be interpreted as errors of concern or warnings -- and what may be ignored for any given purpose. Some virtual reality viewers may well be more tolerant of errors which inhibit the use of others.

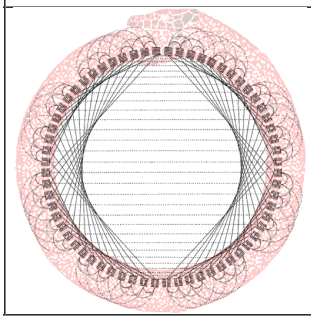
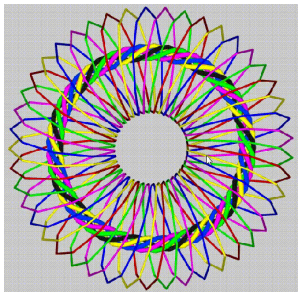
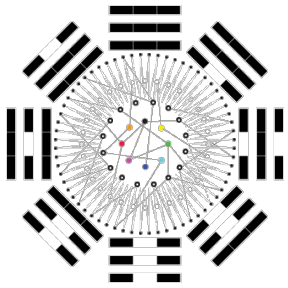
Screen recording: For purposes of communication over the web, as with this document, the interactive dynamics of operation (as seen through a virtual reality viewer) may need to be recorded. Various screen recoding applications are available. The difficulty is the quality of the recording of any movement and how this is translated into a video -- and from there into a GIF animation. A typical problem is the jerkiness which may completely undermine the experience of the original model. Circumventing or eliminating this may require a better recording application or greater skill in its use.

Competing products: The applications available by competing suppliers may well be discouraging -- especially when their comparative advantages, disadvantages and costs are a challenge.

Further 3D design possibilities and metaphors

Toroidal embodiment and being a torus? It follows from previous efforts to present symbols of importance with which fundamental values are variously associated (*Eliciting Insight from Mandala-style Logos in 3D: interactive engagement with mandalas and yantras in virtual reality*, 2020; *Cognitive Implications in 3D of Triadic Symbols Valued in 2D*, 2017; *Reconciling Symbols of Islam, Judaism and Christianity*, 2017).

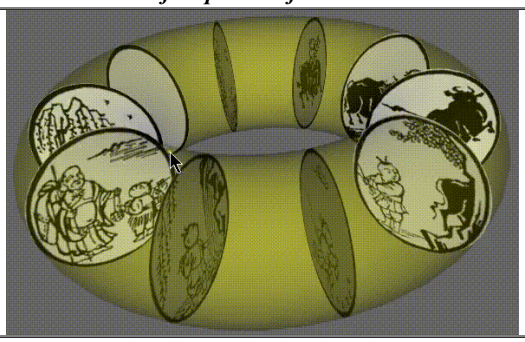
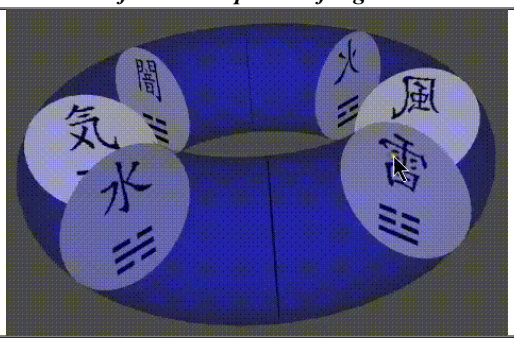
In the light of the challenge of experiencing oneself (or society) as well-rounded, as argued above, is experiencing oneself as a torus just as feasible (if not more so) as experiencing oneself as global or spheroid in some way? The arguments of an earlier section suggest that there is an intuitive appreciation of circlets and ring formation. These could be said to have as much credibility as a global form -- if not more. It could be useful to explore the history of the discovery, appreciation and use of the ball in comparison with the necklace or bracelet -- especially given the importance attached to that of the wheel. (*Toroidal embodiment, knottedness and being a torus?* 2019)

Association of Ouroboros with 64 interrelated conditions of change encoded by the *I Ching*	Animation of helical coils embedded within helical coils indicative of an engendered "magnetic field"	Suggestive animation of circulation of relationships based on *BaGua* trigrams
		

Toroidal representation Zen ox-herding images: The approach developed here could be further adapted to any set of coherent set of symbols, as illustrated separately in the case of the Zen ox-herding images (*Circular configuration of cognitive phases framing toroidal experience?* 2017) forming part of a more general discussion (*Zen of Facticity: Bull, Ox or Otherwise? Herding facts and their alternatives in a post-truth-era*, 2017)

In terms of comprehensibility and memorabilty, of interest is the possibility of presenting the pattern of "bulls" within a torus (as shown below, left). For comparison, and in contrast with those above, te same approach may be used for any potential correspondence with the *BaGua* trigram pattern (below right). Such a depiction, especially when animated, evokes other ways of thinking about both in dynamic rather than static terms, as **phases in a cycle** rather than as stages in a linear progression. The representation is also helpful in suggesting the manner in which **the phases may coexist, if only potentially**, rather than each being superceded by the next. Any assumption of non-reversibility of time may also be called into question.

Variants of the animation may then enhance imaginative consideration of this possibility, as implied by other variants which could be produced (as noted below).

Animation of simplest torus as container for dynamic cognitive relations	
10-fold pattern of Zen bulls	***8-fold BaGua pattern of trigrams***
	
(also video, wrl and x3d versions)	(also video, wrl and .x3d versions)

Options for disk dynamics within the torus -- with cognitive implications
rotation of torus with disks in fixed position (and reversal of that rotation)
spin disks on their axis in a fixed position within the torus
disks moved independently through the torus whether in a coordinated manner or randomly
move disks such that some are periodically merged/conflated (thereby reducing the number of distinctions made)
rotate disks in a fixed position such as to function as valves (opening and closing) in relation to notional circulation through the torus
increase/decrease diameter of disks
move disks across torus -- inserted into new positions (as with Earlier and Later Heaven arrangements of *BaGua*)

Use of the torus usefully frames the question as to what might be understood as circulating through the "tunnel", as can be variously discussed (*Circulation of the Light: essential metaphor of global sustainability?* 2010; *Enactivating a Cognitive Fusion Reactor: Imaginal Transformation of Energy Resourcing (ITER-8)*, 2006). The forces channelled through the major axis are well-illustrated metaphorically in the case of electromagnetism with the operation of a solenoid.

Toroidal version of the Zodiac: Use of the symbolic language associated with the Zodiac has long been deprecated by science and religion despite its popular appeal as a meaningful framework. As noted above, of particular interest is the adaptation of that framework as a "Rosetta stone of meaning" to indicate principles of control and navigation of a vehicle from an engineering perspective (Arthur Young, *Geometry of Meaning*, 1976). This is discussed separately (*Criteria for a Rosetta stone as a meta-model?*; *Geometry of meaning and cognitive embodiment?*, 2016).

It is appropriate to note the care with which Young develops his argument from the abstractions of the physics of movement required in the control of a vehicle such as a helicopter. The terms from the zodiacal framework are only then attributed to offer a degree of qualitative comprehensibility to the distinctions he makes for which he repeatedly notes the inadequacy of words -- given the manner in which they can be variously interpreted and understood. Emergence of deeper understanding is of course characteristic of any learning process -- which may last many years.

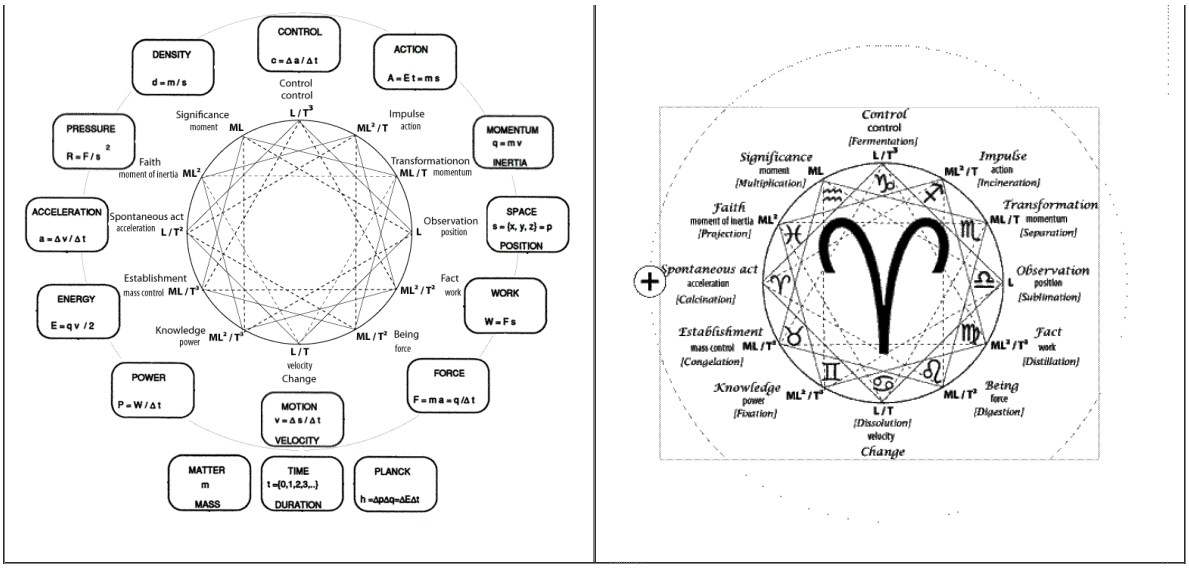
As a focus of astrology, the Zodiac lends itself to an adaptation similar to that above with *Yi Jing* hexagrams. As noted earlier, one approach would be to use a Star of David representation of hexagrams as a framework for 12 Zodiac signs positioned around a torus.

The following experimental animation -- in circular form -- integrates points made by Arthur Young, as variously described and discussed separately (*Geometry of Meaning: Examples of Integrated, Multi-set Concept Schemes, Annex 1*, 1984; *Functional Complementarity of Higher Order Questions: psycho-social sustainability modelled by coordinated movement*, 2004). Prior to its association with the Zodiac, Young used a simpler circular representation in the light of the physics of controlled navigation from which his insights derived (*Configuration of states, acts and relationships*). Relating creativity of such as Tesla to widespread understanding of the zodiac is especially valuable as an aid to comprehension and reflection on the navigation of the conceptual universe -- of the noosphere.

The circular presentation of the table by Young in relation to his arguments with respect to the pattern of the Zodiac is presented on the left below -- tentatively augmented with the 15 fundamental concepts of Arnopoulos (2000), as discussed separately (*Global insight implied by circular representation*, 2014; *Correspondences between juggling and governance*, 2018).

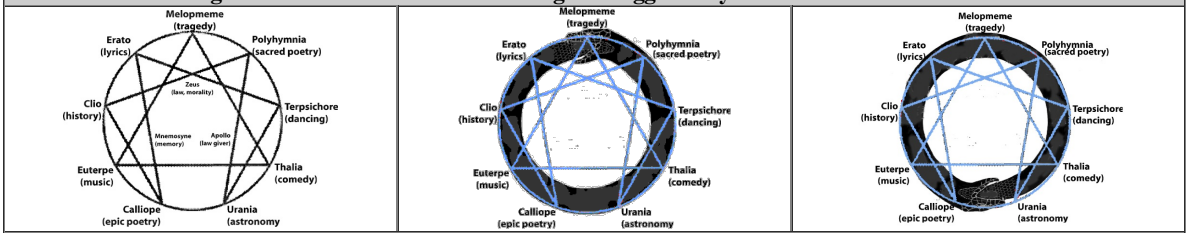
Note that 3 of the Arnopoulos's concepts have been set below, arguably because they do not lend themselves to direct experience in the same manner as the other 12. An animated variant on the right below is an effort to show how these are associated with the creativity held to be engendered by alchemical processes encoded by the forms of Zodiacal signs (adapted from *Eliciting a Universe of Meaning: within a global information society of fragmenting knowledge and relationships*, 2013).

Interrelationship of Zodiac as a "Rosetta stone of meaning" with sociophysics and alchemical processes (tentative)	
"Rosetta stone of meaning" of Arthur Young associated with categories of sociophysics	Experiential system of interwoven creative processes using an alchemical metaphor (animation of the pattern on the left)



Toroidal implication of the enneagram: Clearly the arts associated with the Muses, as valued in the Greek and Roman civilizations, merit consideration as "gatekeepers" of the cognitive mirror. They are the personification of knowledge and the arts and the associated inspiration for literature, and science -- now celebrated in the role of "museums". The role of poetry is clearly recognized by them and related to that of astronomy -- surprisingly. Exploratively ("inploratively"?) they are configured below by attributing them, arbitrarily, to the classic form of the enneagram as discussed separately (*Warp and Weft of Future Governance: ninefold interweaving of incommensurable threads of discourse*, 2010). The pattern on the left is then superimposed on the Ouroboros in the image on the right

Configuration of the Muses on an enneagram suggestively associated with the Ouroboros



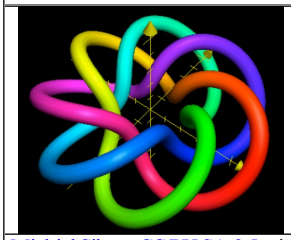
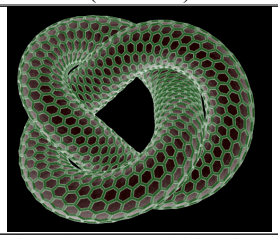
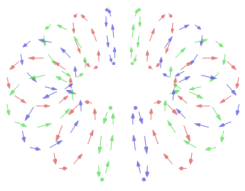
The paradoxical mirroring of a participatory multiverse -- without and within -- is appropriately noted by the title of a work by Joseph Campbell *The Inner Reaches of Outer Space: metaphor as myth and as religion*, 1986). However it is appropriate to note the pioneering work of Marsilio Ficino of half a millennium ago in writing what amounts to the imaginative reframing of everyday life: *De Vita Coelitus Comparanda* -- as described by Thomas Moore (*The Planets Within: the astrological psychology of Marsilio Ficino*, 1990), and separately discussed (*Composing the Present Moment: celebrating the insights of Marsilio Ficino interpreted by Thomas Moore*, 2001). The above argument follows from an earlier speculation (*Being the Universe: a Metaphoric Frontier -- co-existent immanence of evolutionary phases*, 1999).

Toroidal twisting and knotting: Consideration could be given to transforming the torus from its simple circular form by variously twisting it as implied by some traditional images of the Ouroboros.

Contrasting depictions of the Ouroboros -- and its associations with the infinity symbol

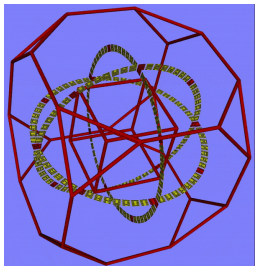
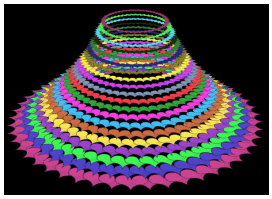
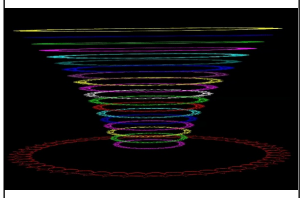
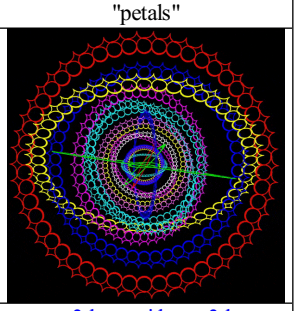
There are many depictions of more complex forms of the torus, most notably as a torus knot.

Indication of complex toroidal dynamics

Torus knot	**Toroidal knot** (animation)	Animation of vortex ring	**Neo-Riemannian Tonnetz** (animation of a toroidal view)
			
Michiel Sikma, CC BY-SA 2.5, via Wikimedia Commons	Adaptation of a model developed by Adrian Rossiter with Antiprism	By Lucas V. Barbosa - Own work, Public Domain, Link	By Davidwbulger - Own work, Public Domain, Link

torus with holes -- scales ****

Toroidal multiplication and interlocking: Such 3D possibilities can be extended by rotating and interrelating circles of hexagrams, as shown below left (*Toroidal constraint -- nuclear fusion as metaphor of cognitive fusion*, 2019). This formed part of a discussion of *Framing Cognitive Space for Higher Order Coherence* (2019). As indicated above, the significance of the crown metaphor is also evident in the cognitive role attributed to the crown chakra (*Sahasrara*) of Hinduism, discussed separately (*Global Insight from Crown Chakra Dynamics in 3D? Strategic viability through interrelating 1,000 perspectives in virtual reality*, 2020).

Indication of complex toroidal dynamics			
Rotation of mutually orthogonal circles of 64 hexagrams	Crown chakra as a set of 20 moving rings of 50 "petals"	Crown chakra inversion of 20 moving rings of 50 "petals"	Gyroscopic movement of selected chkra rings of 50 "petals"
			
x3dom;video; x3d	x3dom; video; x3d	x3dom; video; x3d	x3dom; video; x3d

References

Paris Arnopoulos:

- Sociophysics: Cosmos and Chaos in Nature and Culture. Nova Publishers, 1993
- Sociopolitics: Political Development in Postmodern Societies. Guernica Editions, 1995
- Braiding the Triadic Codex and Triple Helix: the sociophysics of nature-culture-nurture and academy-industry-polity. Paper for Third Triple Helix International Conference (Rio de Janeiro, 2000) [text].
- Sociophysics and Sociocybernetics: an essay on the natural roots and limits of political control. 2001 [abstract]

Anagarika Govinda. The Inner Structure of the I Ching; the Book of Transformations. Weatherill, 1981

David Mumford, Caroline Series and David Wright. Indra's Pearls: the vision of Felix Klein. Cambridge University Press, 2002 [summary]

Joel R. Primack and Nancy Ellen Abrams:

- The View from the Center of the Universe: discovering our extraordinary place in the cosmos. Penguin/Riverhead, 2006
- The New Universe and the Human Future: how a shared cosmology could transform the world. Yale University Press, 2011

Hellmut Wilhelm, Richard Wilhelm, et al. Understanding the I Ching. Princeton University Press, 1995

Richard Wilhelm, Cary F. Baynes, et al. The I Ching, or, Book of Changes. Princeton University Press, 1950 [summary]

Arthur M. Young:

- Geometry of Meaning. Delacorte Press, 1976
- The Reflexive Universe: Evolution of Consciousness. Delacorte Press, 1976
- The Bell Notes: a journey from physics to metaphysics. Delacorte Press, 1979