Living in Hyperscale: Internalization as a Search for Reunification

Ron Cottam*, Willy Ranson and Roger Vounckx

The Evolutionary Processing Group, Vrij Universiteit Brussel,

Pleinlaan 2, 1050 Brussels, Belgium, ricottam@etro.vub.ac.be

*Correspondence can be directed to this author, as the primary contact.

Abstract

Living organisms survive through their generation and use of internal models of themselves and of their environments. *Homo sapiens* internalizes the environment through modeling in such a way that it can effectively be artificially present at any number of different external locations. While this capacity is clearly advantageous for survival, it may well have yet another 'meaning'. We believe that entities internalize their environment in a local attempt to reunify the fragmented global landscape of which they are a part. This paper charts the argumentational route which must be taken to justify this hypothesis.

Keywords: hierarchy; hyperscale; internalization; unification.

Introduction

Our lives are controlled by the impossibility of constantly and unambiguously reconciling our individual desires with those of the society of which we are a part. Peaceful coexistence demands the regular intervention of diplomacy and negotiation. But science rarely calls upon such services, and presupposes that ambiguities outside the constraints of Heisenberg's propositions indicate inaccurate measurement, rather than true inconsistency. Why is this? The various Grand Unification attempts which have appeared in Physics during the past fifty years have all maintained that if the ultimate small-scale target of reductionism can be modeled using some single formally logical mathematical approach then we can say 'we have understood everything'. But, as Rosen (1991) has pointed out, the completely syntactic correspondence of analytic and synthetic models of a natural system is a rarity, if it ever exists *at all*.

Reductionism can tell us what we get when we disassemble a system, but not in general what we get when we reassemble it. This disconnection between *the local* and *the global* is central to our everyday lives, but it is absent from science, except apparently in phenomena related to the esotericism of quantum mechanics, from which, however, it is banished by the use of probability. The perpetual conflict between individual medical wishes and social medical preference provides an exemplary field. Patient demand for powerful antibiotics feeds the evolution of resistant bacteria, which then require ever more powerful antibiotics; but individual patients appear to be unwilling to die (!) as a contribution to limiting this vicious circle.

Aristotle postulated the existence of *final cause* with respect to a specific context, but in a *truly* multi-scalar environment (Cottam *et al*, 2003, 2004a) final cause depends *completely* on where we are looking from: *final cause* is a *localized* property! However, the very nature of awareness, and indeed of science, resides in the imagination of a reasonable, if inaccessible, view of our *internalist* locality from an *externalist* 'god-like' position. Science possesses no absolute grounding from which it can proclaim "this is the truth!" – it consists of an extensive self-supporting network of models, coupled to a wide-ranging panoply of measurements and observations, justified by reference to the entire recorded history of human endeavor and experience. In a specific context, science effectively proclaims "*this* seems reasonable from *this viewpoint*", where the viewpoint is presumed to be in harmony with all others: science *presumes* unification, as does *final cause*.

In this paper we will address the age-old human cry of "Why are we here?" as an important example of local-global discontinuity, and in doing so we hope to successfully illustrate a manner in which some degree of local-global resolution may be achieved. We will present the hypothesis that the construction by aware entities of internal models of an external environment is a *local* action which is instinctively directed at achieving *global* reunification of a previously fragmented universe. Long familiarity with Darwinian evolution leads us to easily accept that our existence depends on purely random processes associated with pressures to survive. However, this is a particularly localized version of Aristotle's final cause: the modalities of life may well be understandable in terms of survival but, as usual, resolution of one question immediately throws up another! Survival is hard work: why bother? Our purpose in this paper is to suggest why entities in Nature do, however, bother to chase after survival. We will argue that survival as a final cause is associated with the duality of localization and communication, of individual and society, and that it is an unfortunately mistaken reaction to consequences of the 'big bang'.

Summary of the Argument

Over the past few decades *Homo sapiens* has progressively moved away from a society based on *analog* representation and control to one which more and more relies on *digital* techniques for its logistics and entertainment. Sadly, while being exceptionally useful, the wholesale adoption of a presumed digital excellence is merely symbolic of an imagined analog perfection. Even though digital techniques expand the possible dynamic range of musical recording, for example, they also truncate the rendition of its detail and inject audible quantization errors.

Analogously, we believe that *evolution* embodies the perpetual struggle of *all* our universe's localized aware entities to return to the delocalized *analog* intercommunicative state of their origins by manipulation of their individual beings and surroundings. Unfortunately, the information loss inherent in their localization blinds them to the original state they seek, and they inadvertently replace their true target by the energy-dependent realm of *digital* inter-local communication.

Our central thesis is that aware entities attempt to circumvent the catastrophic consequences of this error by creating their own internal world, which then both usefully mirrors the external one and provides its owner with the emergent all-inclusive comfort of a simulated universal reunification, in a manner similar to that generated through the non-Euclidian geometry of Van Gogh's painting of the 'Bedroom of Arles' (Heelan, 1998).

Organization of the Argument

To arrive at our central thesis we will need to traverse a wide range of sometimes radical ideas. Before jumping in at the deep end we will sketch out the route we will take, starting from the final statement of our thesis and working backwards to locate a suitable starting point. For each stage of the journey we provide below the title of the relevant subsection of "The Argument". The finale of our presentation appears in the section of the paper which then, entitled "Organic Desire ad Inorganic Longing."

An important consideration in establishing our final thesis is that of strong characteristic similarity across the gamut of *both* 'abstract' *and* 'real' localizations of our environment ("*A Categorical Split, or a Continuous Progression?*"). To justify this conflation we will need to escape from the prevailing dualistic view of Nature, by demolishing its 'abstract'-'real' precursor ("*Mind-Body Duality*"). Oddly enough, we will approach this justification by first suggesting how a *distinction* between 'awareness' and 'consciousness' may evolve ("*From Awareness to Consciousness*"), this somewhat surprisingly based on the assertion that *everything* we experience is a part of awareness ("*Nothing But Awareness*")! This assertion derives from the argument that science has based itself on a false supposition that Nature's constituent 'material' is independent of the scale *at* which, and *from* which, it is observed ("*Energy or Awareness?*"). An important element is our concurrence with David Bohm's expressed view that the different scales of Nature all exhibit their own form and degree of awareness ("*A Commonality of Awareness*").

A central issue is the necessity to establish neutrality with respect to our place in Nature – neither adopting a mandatory self-depredatory position nor an egotistical human-centric one. We ground this neutrality in the birational complementarity of entity-ecosystemic relationships ("*Ecosystemic Birationality*"), following the downfall ("*Dethroning Anthropomorphism*") of both the late twentieth-century's evolutionary reaction ("*... or Anti-Anthropomorphism?*") and its nineteenth-century elitist precursor ("*Anthropomorphism*"). Before we can resort to the prescriptions of ecosystemic birationality, however, we must first go back and examine how different systemic scales relate to each other, in both a top-down ("*Scalar Slaving*") and bottom-up ("*Scalar Genesis*") manner. And suggest how it has come about that our universe exhibits scale, and multiple scales, *at all* ("*Not With a Bang but a Whimper?*" – a quotation from *The Hollow Men* by T. S. Eliot)!

We will argue that there is a strong relationship, even an identity, between *hyperscale*, as the essential manifestation of a natural hierarchy, and its central unifying organization through internal modeling ("*Hyperscale and Transparent Modeling*"). Most particularly, we will relate systemic *hyperscale* to Metzinger's model relating the internalization of external stimuli to an 'illusory mind' ("*Metzinger's Transparent Self-Modeling*"), and to Rosen's categorization of 'life' as the systemic internalization of Aristotle's *efficient cause* ("*Internalization*").

Our starting point, therefore – the first, critical step in our argument – will be to characterize *a system* in a way which explicitly takes account of the essential correlation between *both* its internal differentiation *and* its unification ("*Hyperscale*"), by reference to hierarchical structure ("*System Hierarchy*") and internal communication ("*System Unification*").

It is important to note that all of the considerations we refer to in this paper are relative to the human condition, and from our own time. There is no possibility of justifying an absolutist externalist viewpoint, except as a hypothetical model. Consequently, as far as possible we will attempt to adopt a position which is independent of 'facts', other than those which have been extensively justified by measurement and comparison within the usual self-referential network of science. Any statements which appear otherwise should be understood as hypotheses, derived from extensive consideration across as many aspects of human activity as possible, and which we consider constitute a new self-consistent framework capable of containing science as it is currently practiced and understood.

The Argument

We now have our starting point – system unification – but the reader should notice that in progressing through the argument from beginning to end

we will follow a circular trajectory: the end point of our journey is *also* a form of unification! Rosen (1991) has described *living* systems in terms of closed functional loops of efficient cause. But if efficient cause is internalized as a functional loop, which starts from a specific location with a specific character, and returns to the same location with exactly the same character, then the resulting system is *not* alive – it is 'dead'. This conclusion would also hold for the argumentation we present here: if we were to start from 'system unification' and end up at *the same* 'system unification', the argument we are describing would *also* be 'dead', where in *both* cases we could re-describe 'dead' as 'lacking evolution'. Clearly, however, this is not the case, as the logical process we are describing is one of internalization, or *replacement* of the environment by its *enclosure*. This will appear later as a vital part of our hypothesis, but first, let us advance the supporting argument.

System Unification

The word *system* is a standard way of describing a functioning entity which operates as if, or appears to consist of, an assembly of individual parts which necessarily communicate with each other for the implementation of that function. A system is, by its nature and description, unified – or at least, we *believe* it to be so. The central characteristic of any system is that its individual elements and scales are all unified in a single procedural-structure by Quantum-Mechanical entanglement (QMe). Where this is naturally available between the various parts of the system it can occur internally. Where it is not naturally available, for example in fragmented high-level digital information-processing systems, unification is provided by the QMe of the designers' and/or users' brains (Cottam *et al*, 2004b).

All systems exhibit some kind of scalar characteristic, even if this is just the combination of 'external appearance' and 'internal workings'. System unification takes place through the medium of inter-scalar correlation, generating a 'scale-free' *hyperscalar* 'representation' (Cottam *et al*, 2004a) which to the system or its 'owner' *is* the system. But first, we must look at system *hierarchy*, within which *hyperscale* reigns.

System Hierarchy

The notion of *hierarchy* appears in many guises: as a political structure; as a business organization; as a scalar classification of Nature; as a layered assembly of differently specified descriptions. While commonly some sense of power or control is involved, this is not always the case, and even if it is the ways in which control is localized and transferred may be very diverse. Stan Salthe (1985) has described many of the features of *scalar* and *specification* hierarchies – two of the most important hierarchical models, but here we will concentrate a more general formulation, that of a *model* or *natural hierarchy* – described by Salthe as "a specification hierarchy constructed in terms of scale". We will here restrict our comments on natural hierarchy to properties which are relevant to our present purpose; an overview can be found elsewhere (Cottam *et al*, 2004a, 2003).

Natural hierarchy is based on the concept of *measurement* as a *mutual observation*. Entities at a specific scale can only perceive other entities through their own, naturally limited, perceptual apparatus. For example, our own visual observations are restricted to objects larger than a micrometer by the wavelengths our eyes are able to detect. Natural hierarchy is therefore constructed in terms of *perceptual scale*, and not merely 'scale' as an indication of size. Consequently, there is no sense of 'independence' to any of the scalar levels in a natural hierarchy, as all of them are coupled and stabilized by the requirement for mutual perception.

Any given entity can *always* be described as a natural hierarchy – even though its origin may be completely artificial. However, a *true* natural hierarchy depends for its stability on naturally occurring constraints which result in auto-self correlation of its different scales, whereas a 'convenient' hierarchy depends on arbitrarily imposed external constraints or the imposition of scales, and consequently lacks the cross-scalar correlation of a 'true' hierarchy. The most obvious example of a 'true' hierarchy is an organism; that of a 'convenient' hierarchy is a digital computer.

Extant scalar levels of a true natural hierarchy constitute Newtonian potential wells – regions of systemic phase space where local properties reasonably mirror global ones. Consequently, they exhibit simply-describable properties and phenomena, and the worst local-to-global nightmares of interactions in a relativistic space-time are avoided. Inter-scalar transit in a true hierarchy lacks formally logical description: inter-scalar regions which separate the Newtonian scalar levels are fractally complex in every imaginable manner. However, these complex regions *also* together make up a natural hierarchy. Each Newtonian scalar level is locally complemented by its complex ecosystemic partner, and each hierarchy is the ecosystemic partner of the other.

The complete picture is one of complementary birationality. Not only living organisms, but *all* 'abstract' and 'real' entities in Nature are birationally-associated with their own complementary ecosystems, and the entire universal assembly auto-self correlates as well as it can in the context of a relativistic space-time which has created its fragmentation. The result is *hyperscale*.

Hyperscale

The most recognizable aspect of a system is its *unification*. Although all the myriad differentiations of our environment are necessarily to some extent coupled together, it is usually fairly easy to say "*this* is a part of *this*, and *that* is not". More critical is the balance between inter-elemental *cohesion* and intra-systemic *adhesion*. Nowhere is this (usually) more obvious than for a living organism, where the loss of *functional* cohesion resulting from elemental separation precludes successful functional reassembly.

Unification of a true natural hierarchy abides in its system-wide complementary inter-scalar and inter-complexity correlation. If the character of a single Newtonian scale experiences change, even marginally, then the entire assembly of Newtonian levels will re-correlate to assimilate the change. This unification is beyond individual scale – it constitutes the optimization for some internal purpose of all the systemic scales. This is *hyperscale* – the true nature of natural unification. Similarly for the complex inter-scalar regions, which correlate and re-correlate to assimilate change, yielding a second *hyperscalar* character, complementary to the first. Here again, birationality holds sway. It is only with cross-correlation of these two hyperscalar representations that birationality is finally put to rest, and a *singular* systemic character emerges – as the system's *final cause*!

Biological cells can portray themselves to their surroundings in whatever manner they 'wish', by enclosing themselves in an 'impenetrable' lipid membrane and then opening up the communication channels they require. Their survival, however, demands effective control of this capacity through (low-level) awareness of their surroundings: they require an embryonic 'mind'. The internalization of hyperscalar information-processing provides the means of managing a selectively-communicative survival strategy, by delivering an apparently multiscalar view of surrounding phenomena and internal events without the computational complexities of inter-scalar manipulation. In a complex, multiscalar, ever-changing environment there is much to be said for the construction of a strategic interface between the simplicity of our thinking and the complexity 'out there'.

But what is the real nature of internalization? And how is it different from just creating internal models which can be used in computing responses to external stimuli?

Internalization

Robert Rosen (1991) has pointed out that a major, if not *the* major difference between organisms and machines is that Aristotle's *efficient cause* is 'internalized' in an organism. How does this relate to system unification? If we compare an organism to a digital computer, 'where' and 'what' is the hyperscalar representation in each case? An organism is *internally* unified – it is a real self-constrained hierarchy. A digital computer is *formally* unified: interscalar correlation is forced out of its physical boundaries by the system clock, whose central function is to eliminate any global-to-local dependencies other than those imposed by design or programming.

As Rosen has shown (1991), Aristotle's causes are inseparable and environmentally-dependent in an organism, but categorically segregated in a mechanistic machine: efficient cause is entirely external to a digital computer. However, it is *not only* efficient cause which is internalized in an organism; it is the *entirety* of its hyperscalar unification. A 'convenient' hierarchy, in the form of a digital computer, can *simulate* the effects of external causes through the use of externally-implanted internal models or their precursors. However, herein lies the problem: a 'convenient' hierarchy can only function *as if* it has internalized some functional property; a *true* natural hierarchy can simulate the effects of external causes so well that they are indistinguishable from 'the real thing' – it can *reproduce* the *reality* of function. This is reminiscent of the *equivalent particle indistinguishability* which is a vital part of quantum mechanics. Metzinger (2004) has proposed that humans make use of this internal/external reproductive indistinguishability to relocate their 'presence', and effectively themselves, in a physically-unconstrained manner.

Metzinger's Transparent Self-Modeling

Metzinger (2004) has presented the hypothesis that we are unable to distinguish between the objects of our attention and the internal representations of them which we 'observe'. When we use a screwdriver, we are at the screw; when we drive a car, we become the car. The most astounding characteristic of this transfer of presence is the way in which we can effortlessly skip between different scales of an overall picture.

Metzinger's (2004) hypothesis provides a credible model for the independence of 'mind'. As he states: "We are systems that are not able to recognize their subsymbolic self-model as a model. For this reason we are permanently operating under the conditions of a 'naïve-realistic misunderstanding': we experience ourselves as being in direct and immediate epistemic contact with ourselves. What we have in the past simply called 'self' is not a non-physical individual, but only the content of an ongoing, dynamical process – the process of transparent self-modeling." However, Metzinger provides no clue as to 'where' we can 'find' this 'self-model', or how it could be internally generated over the aeons of evolution.

An unknown hierarchical external environment can be progressively described through diligent assembly of the stimuli to which it subjects a 'being'. Similarly, an unknown hierarchical being can be progressively described through assembly of the questions it poses of its environment and through its social relations. This constitutes the birational paradigm itself: a system of two mutually-evolvable inter-relating aware localizations, whose 'functions', as entity *or* ecosystem, are interchangeable. The creation of an internal transparent environmental model is automatically and intimately associated with the creation of an internal transparent *self*-model! The ecosystemic containment of a *true* natural hierarchy becomes internalized through the generation and maintenance of its extant scalar levels, creating *hyperscalar* self-constraint as an indistinguishable reproduction of relevant parts of its ecosystem.

Is *hyperscale* the origin of Metzinger's (2004) transparent *self*-modeling *and* transparent *environmental* modeling?

Hyperscale and Transparent Modeling

We propose that long-term evolution of unification-maintaining *hyperscalar* survivalist behavior has resulted in development of the high-level transparent self-model Metzinger refers to. We believe that the 'spotlight of consciousness' in humans is momentarily focused at a single 'location' within a spatio-temporal hyperscalar 'phase space' which we construct from the entire history of our individual and social existences, including the 'facts' of our believed 'reality', numerous apparently consistent but insufficiently investigated 'logical' suppositions, and as-yet untested or normally-abandoned hypothetical models which serve to fill in otherwise inconvenient or glaringly obvious omissions in its landscape.

We (systems) (organisms) relate to our environment uniquely through hyperscale (Cottam *et al*, 2003) – we are present in our environment through hyperscale (Cottam *et al*, 2005) — we are reliant for our survival on hyperscale (Cottam *et al*, 2006) – we live in hyperscale. How can we relate this conclusion to our universal environment, and most particularly to the presumed 'origin' of our universe in the 'big bang'?

Not With a Bang But a Whimper?

We can view the universal 'big bang' as an emergent evolution of asymmetry, rupturing the apparently perfect unification of some previous state. However, even accepting that a first degree of localization is the very nature of symmetry-breaking, it is less than obvious why further (higher) scalar levels materialized and developed into the hierarchical complexity we now observe in Nature. It is debatable whether describing the history of our universe on the basis of a linear time scale is helpful, as it necessarily imposes an instantaneous (!) beginning on 'existence'. Research into events closely following the 'big bang' suggests that the more we approach 'time zero' the more there are things yet to discover. This mimics the history of low temperature physics, where the apparently linear Celsius temperature scale proves to be an approximation to the logarithmic form required to represent effects at temperatures below one degree Kelvin. Similarly, the adoption of a logarithmic time scale not only better represents human-based relativism, it also attractively converts the 'big bang' into a process, rather than an event, and removes the catastrophic generation of 'existence'.

David Bohm (1980) has described Nature as 'implicate order becoming explicate.' His description can also be applied to the 'big bang', but in neither case can we presuppose that there is an initial box full of ready-to-unpack entities and characteristics – these are generated through the 'unpacking' process, or *explication* itself. How this began is lost in the mists of space-time, although science has made great inroads into its understanding – always presuming that the model bears some resemblance to 'truth'! As we pointed out earlier, description of far away events can only be provided relative to the human condition, and from our own time, and 'what happened at or before the 'big bang' is rather like the old conundrum "Which came first, the chicken or the egg?" (the dinosaur?). We believe, however, that the 'big bang' (as a *process*) does indeed make sense, in that evolution can be interpreted as a reversal of the character attributed to the 'big bang': *replacement* of the environment by its *enclosure*.

If we extent this simile to include a pre-'big bang' state as ultimate implicate order, and subsequent events as the 'unpacking' of this to Bohm's explicate order, then we are left questioning *how* the multiple scales of explicated order have become stably 'latched' into place (to use a term coined by Robert Pirsig in his book *Lila*) as the universe we know.

Scalar Genesis

Science hypothesizes that Nature progressively condensed into its current form through a series of scalar levels (…, strings, quarks, electrons…). However, the successful listing of scalar levels does little to advance understanding of the way our substantively hierarchical environment has developed, or the way our substantively hierarchical minds have come into being and operate. The basic question appears to be this: given a 'collection' of nominally independent entities, how can it come about that they interact to create a simpler (higher-level) representation of themselves. A vast number of other questions then pop up, for example, do the entities create a new representation themselves - in a manner usually referred to as self-organization – or are there other forces at work.

How should we begin to describe such an initial 'collection' of entities? Certainly not solely in terms of preexistent common properties, as this presupposes that a soon-to-appear higher-level representation *already* exists! But some commonality is clearly in evidence: individual members of the 'collection' have become differentiated as part of a common process; they exist within a common environment.

Compression of a gas provides an excellent analogue to scalar genesis. If the gas (no fixed size; no fixed shape) is sufficiently constrained it will change phase to a liquid (fixed size; no fixed shape). If the liquid is again sufficiently constrained it will change phase to a solid – usually a crystal (fixed size; fixed shape). There is, however, a fundamental difference between the genesis of scale in a true hierarchy and the physical phase changes of liquefaction and solidification. Physical phase changes can invariably be reversed (which is not to say that they are reversible!), as the external driving constraints remain just that – external. True hierarchical scalar genesis cannot be simply reversed – it is a 'latching' process, within which *external* constraints are converted to *internal* ones.

We can ask a number of pertinent questions about the solidification of liquid 'collections' of atoms or molecules. Why does arsenic form crystals with such odd electronic properties? Why do the group IV elements and the III-V and II-V compounds all form similarly structured crystals with such closely resembling elastic anisotropies? Why does water form so many different kinds of ice? All of these follow from the feasible directions of an individual atoms' bonding to other atoms. However, it is the character of a potential higher scale which determines whether the constraints

inherent in an available 'collection' of lower level entities is sufficient for its *emergence*. For example, freezing to a *spatial* solid depends on the feasibility of *spatially* constraining the molecules of a liquid; assembly of two-dimensional shapes to create a continuous surface depends on the geometry of the shapes – a continuous surface cannot be constructed using pentagons!

There has to be some kind of commonality between members of a collection before a next higher scale can form, but also the development of a next scale will *engender* commonality in the individual members, in the same way that our inclusion as humans in human society coerces us to act in 'acceptable' ways.

Scalar Slaving

What makes a flock of birds in the air change direction as one? They appear to operate as a single directed entity, although exhibiting some degree of temporary individual misdirection. At one end of their scale of awareness the individual birds must be able to recognize environmental characteristics which act as amplifiers of individual deviations, as the flock itself has no capacity for awareness. At the other end of the scale the individual birds must *care* whether they are part of the flock or not. Individual movement is directed by coupling between these two extremes of external global constraint and internal individual constrainability. Although it is not very clear why birds fly as flocks, the similar phenomenon of fishes' congregation in schools appears to be a survival mechanism, as an individual is less exposed to predators if it is part of a large grouping of similar fishes.

The relation between scales from group to constituent individuals is one of *slaving to similarity*. A collection of loosely related individuals who congregate into a higher-scalar level, or flock, or school both *become* and begin to *act* in conformity, and an orthodoxy of cooperative coexistence evolves. An important facet of scalar genesis is that it is *only* possible to generate a new, higher scalar level if slaving of the constituent elements is possible (for example, liquid helium cannot be solidified by simply reducing the temperature, as the small mass and extremely weak forces between the helium atoms prevent the atoms being 'slaved' into regular array as a crystal. Scalar genesis and scalar slaving make up a birational complementary pair of processes.

It is notable that, in common with traditional conception, we have described slaving *only* with respect to living entities. But should we so categorically segregate our 'environmental cousins' so simplistically into the alive and the inanimate?

Anthropomorphism

The traditional *Homo-sapient* view of Nature maintains that objects and organisms are essentially different. The history of this viewpoint's development is very complex, and given this historical complexity it is often easier to accept that 'things are as they are usually described' rather than to poke around in descriptions which are part of the understanding of our own nature. This 'acceptant option', however, is inadmissible in our current exercise! The ancient Greek philosophers bore witness to attempts to de-mystify our surroundings, most obviously in Aristotle's replacement of Plato's deistic explanations by human experience and definition. By the nineteenth century, *man* - as a generic term including, of course, *woman* - had come to see himself as God's equal, in his newly found engineering capabilities and unfettered horizons, but he was not yet sufficiently self-confident to dethrone his deistic *sibling* and fully embrace atheism. Not so in the twentieth century, most particularly as a result of the abrupt rise in technology engendered by the global conflict between 1930 and 1945: science now began to take its 'rightful place' in the scheme of things, thus demonstrating that *man* was self-sufficient, no longer needing to rely on divine influence to control his fate.

One important aspect of *man's* rise to dominance - at least, as seen by himself - was the historical establishment of a view of Nature which presupposed a preliminary separation of 'distinguishable entities' into 'the living and the inanimate' (not forgetting the 'inplantate'), followed by the interesting (!) construction of a hierarchy of 'the living' which included an abrupt differentiation between *man* at the summit (created, of course, in God's image) and 'the rest' (where *man* did not always include 'animals resembling the auto-referential *man*, but being of different colors' or even *woman* - explicitly included above). A natural consequence was the wholesale adoption of anthropomorphic descriptions of natural phenomena. Reasonably, human nature could take no other course: if *man's* sibling God had created *man* in his own image, then it behoved upon *man* to explain Nature in *his* own image!

The progressive demise of belief in God during the twentieth century created instability in the transfer of *man's* quasi-deistic character to his descriptions of Nature, and resulted in a radical rethinking of his place in the scheme of things.

... or Anti-Anthropomorphism?

Given the apparently general applicability of system theory, and the universal dependence for unification on QMe which we noted above, is *man's* reliance on an overarching anthropomorphic position sustainable? Clearly not. The end of the twentieth century witnessed its violent rejection, and any connection between human and Nature's characteristics was expunged. The result of this *anti-anthropomorphism*, however, was arguably even worse, as it completely decoupled *man* from his environment! One consequence was the associated automatic acceptance that evolution was uniquely 'directed' by random processes: that is to say, it was not directed *at all*!

Dethroning Anthropomorphism

The common aspect of *anthropomorphism* and *anti-anthropomorphism* which concerns us here is the categorical separation of 'distinguishable entities' into 'the living and the inanimate'. We see no reason why this categorical separation should be maintained. Our own view is that 'life' is a label which we stick onto some entities and not on others without looking any further into whether it is a defining characteristic or not. We have published elsewhere (Cottam *et al*, 2005) arguments in favor of non-self-referential 'definitions' of life (for example, in terms of joint digital-analog coding as proposed by Hoffmeyer and Emmeche, 1991), but the central issue here is whether we can understand the 'whys and wherefores' of life, and not whether we can say "this entity is alive, and that one is not". Ego is a powerful mover: we will have to dethrone ourselves from the wrongly-presumed pinnacle of evolution to address these questions. Over the past 50 years, evidence from anthropological studies has been growing that the 'exclusively human' characteristics which we hold most dear can be found in other species. The long-held supposition that 'lower animals feel no pain' is now 'on its last legs'. Thompson and Ogden (1998) have impressively demonstrated that while macaque monkeys and pigeons cannot use analogy as a tool, chimpanzees can and do on a regular basis (Ogden *et al*, 1998). The internet-published video of Betty the crow manufacturing a hook from a piece of wire to get hold of food (Weir *et al*, 2002) was a shattering revelation!

The dethronement of *both* anthropomorphism *and* anti-anthropomorphism leaves us with a descriptive vacuum to fill. Fortunately, within the same time period that anti-anthropomorphism took centre stage, the environmental movement and 'the ecosystem' were 'born', arguably dating from the publication in 1962 of Rachel Carson's (2002) book 'Silent Spring', and the stage was set for a yet another revolution related to anthropomorphism – that of *man* as *a part of* Nature!

Ecosystemic Birationality

If a pendulum is held to one side and then released, it will first swing to the other extreme, before damped oscillation leaves it finally in a position of stable equilibrium. So it is with points of view which are artificially held to an extreme position – and so it has been with *man's* relationship with Nature. Release of the deistic constraint to anthropomorphism resulted in a radical switch to anti-anthropomorphism, before the ecosystemics of the environmental movement penetrated into anthropology. Our propositions continue this progression away from attributing special status to *Homo sapiens*, and support the view that although evolution acts as a scavenger, adopting previously developed characteristics for new purposes, it is in general possible to trace back from current attributes to their historical, if very different, precursors. As plants and animals are simply (!) a part of Nature, so is *Homo sapiens*, and so are apparently 'inanimate' materials and objects.

True natural hierarchy possesses the ecosystemic characteristics of the environmental movement, but it goes much further in its self-consistent birationality and the *hyperscalar* unification it exhibits, and in its *universal* applicability to both 'abstract' and 'real' structures. The relationship between entity and ecosystem is a complementary one. It should be noted that simplification of a binary complement can lead to binary orthogonality, or by more extreme reduction leads to a pair of opposites. *Entity* and *ecosystem* are complementary in neither of these simplified senses, but in the complex manner indicated by Niels Bohr: "The opposite of a correct statement is a false statement… but the opposite of a profound truth may well be another profound truth." Consequently, even *formal rationality* itself is subject to the complexity of ecosystemics, as can be anticipated from Gödel's Incompleteness Theorem. An important aspect which is far less obvious, however, is that the rationality operating within an ecosystemic domain with respect to its associated entity is the *complement* of that through which the entity addresses the ecosystem. This is the central characteristic of ecosystemic birationality, and it is the reason that *both* the Newtonian wells of a natural hierarchy *and* the inter-level complex regions comprise natural hierarchies.

Extensive detail of the properties of coupled entity-ecosystem birational hierarchies can be found in Cottam *et al* (2004a, 2003). The only remaining characteristic we point to here is that because of its *universal* applicability to both 'abstract' and 'real' structures, birational ecosystemics can equally well describe both the evolution of physical forms, of animals, of plants, and that of ideas, of logical arguments, and of the human mind.

Given that with the universal adoption of birational ecosystemics we subsume inanimate physics into a new common architecture, we must now address the nature of *awareness*, whose applicable domain will *also* be subject to modification.

A Commonality of Awareness

The last major bastion of 'man's supremacy over Nature' lies in the areas of awareness, consciousness, and most particularly self-consciousness. Interviewed by Weber (1987), David Bohm stated "*I would say that the degree of consciousness of the atomic world is very low, at least of self-consciousness.*" (Weber) "*But it's not dead or inert. That is what you are saying.*" (Bohm) "*It has some degree of consciousness in that it responds in some way, but it has almost no self-consciousness.*" ... (Weber) "*... you are saying: 'This is a universe that is alive (in its appropriate way) and somehow conscious at all the levels.*' (Bohm) "*Yes, in a way.*". These comments are precursors of the hypothesis we wish to support: that awareness, consciousness and self-consciousness are not the sole property of humans, or of mammals, or of animals, or of 'living entities' alone, but that to a degree *all* recognizable differentiated entities are aware of their surroundings, and that higher levels of awareness, consciousness and self-consciousness result from the properties of networked information-processing.

Newton based his mechanics on the 'intangible' grounding of *energy*, from which in a more modern physics all of Nature is supposedly condensed. Newtonian mechanics, however, is only an approximate model, which is reasonably accurate and useful for *near-equilibrium* systems which exclude the *very big*, the *very small* and the *very fast*. Quantum mechanics, on the other hand – similarly energy-grounded but non-local in character

– is considered to be a true and accurate representation of reality, but this entirely misses the central issue. Newtonian and quantum physics are both mono-rational systems. Whereas Newtonian physics is reductive towards localization, quantum physics is reductive towards delocalization: between them they provide a complementary birational ecosystemic description of Nature. Newtonian and quantum physics are orthogonal simplifications of a binary complement. Although conserved energy appears to suitably ground each of the two polar simplifications, is this still the case within their complementarity, or is *awareness* a more suitable candidate?

Energy or Awareness?

Following on from Einstein's (1905) now well-demonstrated proposition that energy and matter are different facets of a single property (i.e. E = mc2), science hypothesizes that the various observable scales of the universe are all material formulations of one constituent - energy. Strangely, in its insistence that both inanimate and living entities are grounded in a single 'intangible material', science itself provokes the idea that living organisms reveal some 'other-worldly' characteristic, and implicitly sets up the 'hard problem' of understanding consciousness. David Bohm's position (Weber, 1987) is clearly opposed to this fragmentation, but also, in common with his more general concept of Nature as the explicate facade of an implicate order, his comments about 'the atomic world' suggest an acceptance that science's categorical distinction between the inanimate and the living may be in error.

We wish to present a view of Nature which corresponds to Bohm's comments to Weber (1987), but one which goes much further, in its formalization of degrees of awareness and consciousness by association with degrees of an entity's subsumed complexity. We suggest that the 'energy' which science uses in its models is a truncated description of 'awareness', where the difference for atomic or sub-atomic 'particles' is negligible, and that both react to constraints in a quantized manner. Although the difference between 'awareness' and 'energy' may be negligible for singular entities or 'particles', we believe that it is amplified in information-processing networks, so that the two may be radically different for complex neural networks.

The scalar levels of a hierarchy are generated through perception. Perception is entirely dependent on the sensorial transduction of incoming signals, lending credence to an argument that signal grounding *is* the nature of a perceived environment. If in a birational ecosystemic universe it is realistic to replace energy by awareness as the grounding medium, then *awareness is everything*.

Nothing But Awareness

It is impossible to categorically separate the static (structural) and active (process) complementary components of system dynamics, most especially when talking about events in the distant past of the 'big bang'. We believe that the primal nature of our universe is precisely this kind of static/dynamic complement, corresponding to a primitive awareness. We therefore assume that awareness is the basic constituent from which our surroundings have condensed. At first sight this appears a little contradictory, as it is difficult to imagine 'awareness' in the absence of 'something to be aware of', but we would remind the reader as we stated earlier that our considerations are relative to the human condition, and from our own time: it is linguistically only possible to refer to the 'original' character of a complementary system *as if* its components were separate!

The universe we are describing, therefore, is one where all interactions are moderated by some kind of awareness or consciousness. Far from being 'inertly reactive', we believe that Newtonian 'billiard-ball' mechanics depends on a local awareness of context, and that 'higher-level' entities (which implies that they constitute larger coherently 'unified' information-processing networks) display greater awareness – most specifically greater *self*-awareness in the guise of Metzinger's (2004) 'transparent self-modeling'.

We are now apparently left with a massive contradiction. Metzinger is describing events and phenomena *of the mind*, supported by the brain as a physical substrate. But where is the mind-body differentiation in a universe consisting entirely of *awareness*?

Mind-Body Duality

It is all very well suggesting that all entities exhibit a degree of awareness, but the traditional view of living systems, at least for our human selves, is that we exhibit two radically different systemic characters, corresponding to the mind-body duality of Descartes (2002). If we are correct in suggesting that everything in our surroundings is in some way aware, should we not, therefore, observe a similar characteristic duality for everything? The only difference we are presupposing between apparently 'inanimate' and apparently 'living' systems is the extent of their information-processing networks. What happens to a system's character as its information-processing network expands?

Looking into a system, we often describe its pathways and their meeting points by the simple picture of a network of interlinked lines and nodes. An example is the ball-and-stick models used to describe molecules in chemistry. The balls represent not only entities, but also communicational nodes; the sticks represent communicational pathways. If all these pathways are similarly specified, whether as globally existing or globally absent, then the system is relatively easy to describe, and it can be described as being minimally complex. If, however, all of the pathways are individually specified, then the description is of necessity far more complex. We must decide very clearly where we are looking things from, as we only have one point of view at one point in time.

A system can be described from an external platform as a set of order parameters. It can also be described from a quasi-external platform as a set of internal relations. This latter corresponds to just about every system analysis which we carry out, but unfortunately in a system which exhibits scale effects internal detail is inaccessible by application of formal rationality! (although conventional science commonly presupposes this not to be the case - and no, we have not forgotten quantum mechanics here). Unfortunately, we cannot equate all the node-linkages, as there are two major types - those where there is a direct link between nodes (i.e. they are 'adjacent'), and those where the linkage is indirect, through one or more other nodes.

Starting from the simplest network, we can extend this distinction of direct and indirect linkages to larger node-and-pathway system models. Given 2 elements, we will have 1 direct link and no indirect ones; with 3 elements there will be 2 direct links and 1 indirect; with 4 elements, 3 direct, 3 indirect; with 5 elements, 4 direct, 6 indirect, and so on. As we move to larger systems the relationship between direct and indirect links takes on a clear form: the number of direct links goes up as the number of elements N, the number of indirect links goes up as the square of the number of elements N2/2. The populations of direct and indirect character in this simple network representation co-evolve at very different rates. For a system with one million direct links, there are a possible million-million indirect ones: for large systems indirect links are likely to dominate massively, depending on the complexity of the relationship between local and global structures.

Even though network topologies do not necessarily conform to this simple model, the character we can attribute to a complete system is ultimately controlled by this direct/indirect balance. So, even in a universe consisting entirely of awareness, there will still be a perception of mind-body differentiation in complex networks – if the information-processing capacity of the perceiving entity is limited!

Awareness is coupled to perception – specifically perception of *something*. How can we explain on this basis generation of the higher level, more abstract 'awareness' we refer to as *consciousness*?

From Awareness to Consciousness

A hierarchy consists of a number of different scalar levels, each one constituting a meta-description of at least its immediate precursor. As we pointed out above, it is not at all obvious how the generation of a new hierarchical level takes place from a collection of entities at a previous one. We have proposed as a paradigm (Cottam *et al*, 1998) that the emergence of metastatic localizations from the nonlocal universal background is nothing other than "the second half" of the quantum-jump which is invoked in transitions between the permitted states of a quantum system.

A metastate depends for its continuance not only on control of its surroundings or context, but also on self-referencing as a means of stabilization: it must exhibit not only external consciousness but also a degree of self-consciousness. Uniquely external consciousness can engender self-destructive development; self-consciousness on its own will leave the entity wide open to attack by external agents. The cooperative duel between these two facets constitutes the process we refer to as life.

We can identify in this manner the entire field of near-equilibrium physics as the minimal description of the universe when it is considered as an 'inanimate' system, or as its ground state when describing it as a single entity or quantum. This then recognizes the ground state of any quantized entity as being equivalent to its description as an 'inanimate' object, higher unoccupied states as higher degrees of a latent or implicate capability for coherent consciousness, and higher occupied states as higher degrees of explicate consciousness itself.

The more effectively a system can compute responses to external threats, the better will be its chances of survival. In order to respond to threats within a limiting permitted time-scale, it is necessary to be able to process sufficient information to evaluate suitable responses, but it is also important for all of that information to be able to auto-correlate. And this has to take place in a causal domain which is characterized by its limited communicative capacity! It is the spatial information-processing density which must be maximized (Cottam *et al*, 1998), and not simply the quantity of processing. Access to causal chaos through complexity provides the means of generating sufficient information density to achieve higher consciousness states, in a manner generic to that of the 'objective reduction' quantum superposition state collapse proposed (Hameroff and Penrose, 1996) for microtubular computation.

In this argument we appear to be equating the characteristics of *all* localized entities: everything senses, is aware, reacts, creates internal models, seeks survival. And yes, that is indeed our intention. But that does not mean all relationships will be linear, or that every property will *appear* to belong to all entities. Things would be seriously amiss, however, if we could not reproduce in our description the apparently categorical distinction we habitually observe between *the living* and *the inanimate*, or the apparent neural superiority of the primates when compared to insects and small animals.

A Categorical Split, ot a Continuous Progression?

The co-evolution of direct and indirect relations in large systems leads ultimately to two different independent systemic characters. One corresponds to the 'normally scientific' view, which depends on formally-rational cross-scale information transport, the other to parts of the holistic system which are inaccessible to a 'normally scientific' viewpoint, and associated with the distributed nature of indirect relations. Complete representation of systemic interactions with an environment requires evaluation of both of these characters. If we simply describe a quasi-externally viewed system in

terms of the reductively specified interactions we miss out the majority of the systemic character, except if we are dealing with time-independent artificial formal 'machines', such as idealized digital computer systems. Even for digital systems, however, the localized/holistic character differentiation remains. A single hardware computer gate or switch has an entirely locally-defined character: it may perform a predetermined AND, OR, NOT... function on its inputs and transfer the result to its outputs, but that is its entire 'meaning' to the computer it serves and of which it is a part. A line of software, however, only has 'meaning' in the context of the entire job the computer is performing: it is effectively part of a more holistic character.

We believe that this bifurcation of systemic character into dual reductive and holistic parts, and difference in rational accessibility between the two systemic characters, has led to the conventional split between body and mind, where the body is naturally associated with direct 'scientific' bio-systemic relations and the 'mind' is naturally 'difficult' to understand in the context of a 'normally scientific' viewpoint which presupposes that all essential systemic aspects can be related to a single localized platform.

But where, in all this, is the distinction between living and inanimate entities? Well, there doesn't appear to be one! The degree of system-character bifurcation does indeed depend on the network size, but in an exponential manner (N2/2). Consequently, we would not expect to observe a linear change in character between 'the inanimate' and 'the living', but approximately separate representative regions with a vague boundary between them. And within the 'living' region we would most probably only notice substantial differences between the two system characterizations at the high end of network size: our human 'superiority' is still safe!

An Extra Mile...

The core of a major question from the introduction to this paper remains. If the value of awareness lies primarily in the support it lends to survival, *why bother*? What, if anything, is the point in survival? And if continued expansion of an information-processing network ultimately leads to the almost-complete internalization of Metzinger's (2004) transparent modeling and self-modeling imbalance, why have survivalist pressures not curtailed the process of internalization long ago?

Organic Desire, and Inorganic Longing

Throughout this paper, and most specifically in this coda to the argumentation, it is evident that the suitable choice of words is problematic. A large part of our linguistic heritage is controlled by its concurrent cultural perspective. May we beg the reader's lenience if our choice of words and expressions appears to be disappointingly anthropomorphic, and therefore in contradiction to our stated aims: this is often so because it would be difficult to phrase things otherwise.

We now have all the elements in place to address our central thesis. We view our universe's evolution, and its entire post-'big bang' history, as an assembly of interacting individual attempts to 'turn back the clock' to the intimate unification of a pre-'big bang' state. Relativity – the cause of localization and differentiation, and the inevitability of inter-locational delay and informational incompleteness – precludes any 'factual' achievement of this aim, leaving only the surrogate possibility of *virtual reunification* through environmental *internalization*.

In the acceptance of a commonality between objects and organisms, and in consideration of David Bohm's position (Weber, 1987), it is implicit that 'everything can *want'*. In common with all awareness-related properties, the character of 'wanting' will depend on information-processing network complexity. *Homo sapiens* expresses extreme degrees of 'wanting' as *desire*: the less defined character of *longing* would appear more apposite for low-level entities. In an evolved state of segregation, an entity will possess at least some awareness of its origins, and can put into practice an aspiration to re-establish global unity. We suggest, however, that evolution is the result of a misdirected search for re-unification by a historical multitude of individuals, which has fed the progressive development of Nature's hierarchy. Relativity permits segregation and differentiation, but also imposes partial isolation and limits an entity's knowledge of its evolutionary history. Informational loss inherent in the emergence of new higher scalar levels misguides the search for reunification towards yet higher, more energetically-dependent digital communicational states, rather than the nonlocally-analog unification of its low-level precursors.

As Metzinger (2004) suggests, entities at the 'highest level' come within reach of the transparent self-delusion of purely internal awareness: they construct integrated hyperscalar models of both environment and self, such that they can no longer clearly distinguish between 'what is inside' and 'what is outside'.

Let us follow through the process of internalization. An entity receives continual stimuli from its environment, which effectively *describe* the environment. In search of survival, the it will be forced to react to these stimuli, and in doing so create internal models of those features of the environment the stimuli reveal. Early in the process of internalization these models will remain just that: recognizable discrete models of external features embedded in the entity's internal modeling of itself. As the process of stimulus-and-response continues, more and more of the internal information will relate to external features, and the entity progressively builds up a more complete and self-consistent network of internal models. Finally it is virtually impossible to distinguish between stimuli originating outside the entity and stimuli generated from internal predictions of external events. The entity can now not tell the difference between itself and its environment, and to all its internal intents and purposes, the entity *becomes* everything!

This seems reasonably to model the emergence of the *ego*, but now unexpected events can provoke internal conflict, and the entity can be simultaneously aware that *it is* everything and *is not* everything. Conflicting viewpoints cannot stably coexist in a mono-rational structure, but in a birational hierarchy they can be assimilated into the systemic complementarity; differentiated entities *always* relate to their ecosystemic surroundings in a birational manner (Cottam *et al*, 2004b). 'Awareness' and 'intelligence' are both associated with the assimilation of multiply-scalar representations into a hyperscalar 'reality', but as the entity-ecosystemic relationship is birational the result is a complementary pair of awarenesses, of self and surroundings, and it is only at the highest level of entity-ecosystemic correlation that the singular systemic property of wisdom emerges as an 'awareness sum'. Below this singular level the two hyperscalar 'summations' will naturally hold different viewpoints: one of these is more closely related to *logic*, the other more closely to *emotion* (Cottam *et al*, 2004a), and the two operate together in adapting to new situations. For a low scalar level entity the vast majority of its 'awareness sum' will be external: witness the survival of Newtonian particles through rule-based interaction. Higher level entities exhibit a greater 'awareness sum', and its internalized component dominates.

Conclusion

We conclude that natural evolution is the search to internalize *everything* as a self-delusional 'transparent self-model' of unification? *Hyperscale* is both the reality of a true natural hierarchy and a globally mistaken but locally seemingly-successful conclusion to the quest for unification. Which leaves us with a difficult question: if our central thesis *is* correct, how does an evolutionary search for unity relate to *gravity*?

References

Bohm, D. (1980). *Wholeness and the Implicate Order*, Routledge, NY.

Carson, R. (2002). *Silent Spring* (40th anniversary edition), Houghton Mifflin Company, New York.

Cottam, R., Ranson, W. and Vounckx, R. (1998). "Emergence: Half a Quantum Jump?" *Acta Polytechnica Scandinavica*. Ma 91:12-19.

Cottam, R., Ranson, W. and Vounckx, R. (2003). "Autocreative Hierarchy II: Dynamics - Self-Organization, Emergence and Level-Changing," in *International Conference on Integration of Knowledge Intensive Multi-Agent Systems*, (H. Hexmoor, ed.), IEEE, Piscataway, NJ, pp. 766-773.

Cottam, R., Ranson, W. and Vounckx, R. (2004a). "Autocreative Hierarchy I: Structure - Ecosystemic Dependence and Autonomy," *SEED Journal*. 4:24-41.

Cottam, R., Ranson, W. and Vounckx, R. (2004b). "Back to the Future: Anatomy of a System," in *Computing Anticipatory Systems: AIP Conference Proceedings 718*, (D. M. Dubois, ed.), AIP, New York, pp. 160-165.

Cottam, R., Ranson, W. and Vounckx, R. (2005). "Life and Simple Systems," *Systems Research and Behavioral Science*. 22:413-430.

Cottam, R., Ranson, W. and Vounckx, R. (2006). "Hyperscale Puts the Sapiens into Homo," *New Mathematics and Natural Computation*, in publication.

Descartes, R. (2002). *Discours de la Méthode*, Editions 10/18, Paris.

Einstein, A. (1905). "Ist die Trägheit eines Körpers von seinem Energiegehalt abhängig?" *Annalen der Physik*.18:639-641.

Hameroff, S. R. and Penrose, R. (1996). "Orchestrated reduction of quantum coherence in brain microtubules: a model for consciousness," in *Toward a Science of Consciousness*, (S. R. Hameroff, A. Kaszniak and A. C. Scott, eds.), MIT Press, Cambridge, MA.

Heelan, P. A. (1998). "The Emergence of New Perspective Practice in Vincent Van Gogh" *Acta Polytechnica Scandinavica*. Ma 91:315-324.

Hoffmeyer, J. and Emmeche, C. (1991). "Code-duality and the Semiotics of Nature," in *On Semiotic Modeling*, (M. Anderson and F. Merrell, eds.), Mouton de Gruyter, New York, pp. 117-166.

Metzinger, T. (2004). "The Subjectivity of Subjective Experience: a Representationalist Analysis of the First-Person Perspective," *Networks*. 3-4:33-64.

Ogden, D. L., Thompson, R. K. R. and Premack, D. (1998). "Analogical Problem-Solving by Chimpanzees," in *Advances in Analogy Research: Integration of Theory and Data from the Cognitive, Computational, and Neural Sciences*, (K. Holyoak, D. Gentner and B. Koichov, eds.), NBU, Sofia, Bulgaria, pp. 38-48.

Rosen, R. (1991), *Life Itself*, Columbia UP, New York.

Salthe, S. N. (1985). *Evolving Hierarchical Systems*, Columbia UP, New York.

Thompson, R. K. R. and Ogden, D. L. (1998). "Why Monkeys and Pigeons, Unlike Certain Apes, Cannot Reason Analogically," in *Advances in Analogy Research: Integration of Theory and Data from the Cognitive, Computational, and Neural Sciences*, (K. Holyoak, D. Gentner and B. Koichov, eds.), NBU, Sofia, Bulgaria, pp. 269-273.

Weber, R. (1987). "Meaning as Being in the Implicate Order Philosophy of David Bohm: a Conversation," in *Quantium Implications: Essays in Honor of David Bohm*, (B. J. Hiley and F. D. Peat, eds.), Routledge and Kegan Paul, London, pp. 440-41 and 445.

Weir, A.A.S., Chappel, J. and Kacenik, A. (2002). "Shaping of Hooks in New Caledonian Crows," *Science*. 297(5583):981