DEBATING REALISMS
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# REAL PEOPLE, REAL SCIENCE, REAL ECONOMICS

by
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## INTRODUCTION

My *reality* is our living environment, being killed by a virus in economics. My *realism* not only posits a persistent reality to refer to, but explains it, given Conservation of Energy, as directional self-reference, ie *looping*, with differences of atoms, personality, scientific method, economics etc involving different ways of looping. The economic "virus" disrupts the *circulation of money*. The medicine points educators to alethic (technological) forms of *information science*, guide of designers of communication channels. This focuses on the directions rather than the forces of reality.

### Context

Behind this paper lies a decade of reflection on the logic of economics, followed by the discovery a couple of years ago that Critical Realists had reached very similar conclusions by another route. To unpack that summary a little, my own route had been via information science, technology and management (within a research environment), with history, philosophy and religion as background. My problematic was set partly by logical issues, partly by Catholic social teaching[1] and partly by communication problems which eventually raised the issue of personality differences. The Critical Realist path seems to have been via Bhaskar's philosophy of social science and Lawson's use of this for economics. We converged after I wrote a paper for a Catholic conference on Globalisation, seeing economic problems historically rooted in the by now anachronistic philosophy of David Hume. *The Chesterton Review*[2] then praised a Lawson article saying the same.

A lot has changed since the 1740's – like radically new insights into the nature of logic and mathematics, with development of information science and its electrical technology. Economics has remained aloof. The Pope, calling for the relief of international debt, is addressing the same problem examined by Adam Smith in the final chapter of *The Wealth of Nations*.[3] That book remains an outstanding analysis of the problems, but necessarily offers eighteenth century solutions. The same solutions are still being offered today.

### Possibilities and problems

Are there then no alternatives to bankruptcy, living within one's means (not always possible for everyone), and charity? I now believe there are. They involve seeing money in terms of *information*: as a symbol, the mere carrier of a promise to pay in kind, rather than a surety for it. The "virus" sees money as *power*, obscuring differences of information. Medievals and Muslims simply prohibited usury (which was reintroduced in Britain by Henry VIII, along with "privatisation"[4]). Information-based solutions can be more subtle.

Our difficulty lies not with these, but in the specialised interests, scientific backgrounds and economic roles of those who need to understand their implications. Most people prefer to leave such matters to the experts (thereby presuming these exist). Practical economists tend to treat their science more like an art form, the art of manipulating "the market", which is to be mastered rather by *achieving* the necessary skills than trying to articulate and criticise them.[5] Scientists have lost interest in information science because its findings have been built into technology, where they are taken for granted rather than reflected on.[6] Philosophy no longer provides an overview, for competitive specialisation rules, with contexts, error types and indexical/logarithmic form still misinterpreted by empirical and existential phenomenologists using class language and arithmetic. (Wittgenstein's "picture" theory gets discussed[7] but not library scientist S R Ranganathan's "wall-picture" principle[8]: the fundamental information principle that without a "wall" to paint it on you can't have *any* picture. Yet that *is* philosophy. Given the wall, the past: is our future - the picture - given? Will it "evolve" or are we responsible for it? Are Chesterton[9] and Bhaskar[10] exceptional *only* because of GKC's interest in personality and Medieval philosophy, Roy's in social realities and Eastern philosophy?)[11].

Since Bhaskar makes no reference to Information Science, even for Critical Realists I have to begin at the beginning: with *intercommunication* between Bhaskar's four levels (arranged as specific and contextual dimensions). Chesterton [12] likened the fixing of meaning via image and symbol[13] to a surveyor's triangulation, which pinpoints the intersection of two directions[14]. I have tried elsewhere[15] to convey how electrical engineers "see" flows concretely through the use of circuit diagrams so as to attach meaning to their mathematics. Conceptually, an electrical power station, its distribution network and its varying loads reduce to an easily visualised generator, distribution loss and useful load. In an even more easily visualised analogy, an economic system is like a central heating system in which water is pumped through pipes and radiators. The point of it is the heat which the circulating water carries, the promise of a livelihood which money income conveys to those in urbanized societies who cannot live independently. The point is the promise, *not* the cash flow, *yet that is crucial from the designer's point of view.*

Design criteria emerge even from these simple models. There is a maximum amount of power or heat which can be transmitted by electrical or heating systems, because trying to convey more creates even greater losses in the wires or pipes. (Cf. the Law of Diminishing Returns in economics). If two circuit paths are in parallel rather than one after the other, the same thing applies. Flows have to be *balanced*. Turn one radiator on full by opening the balancing valve (the one with the loose cap) and you are liable to cool down another. (Cf. the current imbalance between investment and trade, with the former capturing 95% of the money flow and suffering inflation, the latter with just 5% suffering deflation)[16]. If a heating system expands or contracts, then more or less carriers must be provided from a *sink* in the form of a header or expansion tank. Unlike monetary credit at interest, sinks create no destabilising diversion of flows.

The Laws of Circulation illustrated here apply not only to electricity but to electrical systems like brains, to logical systems like scientific methodology, and to monetary economics. Why then are they not familiar? Partly because you can rarely *see* circulation, but also because philosopher David Hume taught scientists not to believe in what you can't see. His economist friend Adam Smith saw gold, promissory notes, "profits" and the advantages of specialisation, so that economic specialisation was already established before electrical circuits were chanced upon and laws of circulation worked out for them. (Neurologists discovered them, yet still do not understand neurological circuits)! Despite slumps, almost the only great economist to develop a designer's feel for monetary dynamics was Keynes,[17] and sadly he was dead before Information Science was founded in 1948 by the seminal papers of Shannon[18] and Weiner[19]: long before Algol-68 programming logic[20] made sense of Russell's paradox[21] and recognition of PID feedbacks in servomechanisms[22] reduced Heaviside's electric circuit theory[23] to a form of logic[24].

## Overview

It is pretty daunting to have to challenge eminent economists, scientists, academics, business men, politicians and educationalists to get up to date, though that seems to be what is necessary. More realistically, perhaps, their successors may choose that way to make their names and secure a future for our grandchildren. Make no mistake: given how industrial economics has diverted resources from care of to exploitation of the natural environment, that is what the issue ultimately is.

Here, my purpose is not to challenge, but to add Information Science to the Critical Realist armoury. Insofar as I am Critical, I am only trying to be more Realist. I cover four areas where the Critical Realism I have so far encountered seems to me to be weak or absent.

On the first, we are agreed, the problem is Hume's ontology (or logic, or theory of truth). Roy Bhaskar, following Kant, has shown there is more to reality than Hume supposed, and I agree with him. What I haven't seen is a *direct* attempt to show that Hume was simply *wrong* (because 'cause' implies transformation, not existence), that information *can* pass the sensory barrier (the method not being what Hume supposed), that you *can* derive an 'ought' from an 'is' (the logic not being what Hume presumed), that it is not a mere assumption that there *are* persistent objects as well as sensory events (the physics of Hume's time just not being up to showing it). All this follows naturally from information science, but I have to say the argument and any failings in it are entirely my own.

Secondly, I come to what in my experience is a major issue, the reality that people are different, have different types of interest, motivation, sensitivity, imagination, judgement etc quite apart from differences in background and education, so that even people who live or work together can fail to really understand where the other is coming from.

Just a few years ago I was introduced to the Jung/Myers-Briggs personality analysis[25], and suddenly, after forty years of confusion, my wife's conduct and other's difficulties with mathematical concepts became almost totally intelligible. I had already worked out the brain functions involved and

could see immediately how their combinations operated. Reflecting on my life in scientific research, I could see why different types of people ended up in different jobs, and thus that the jobs themselves were different. From the points of view of environmental politics and changing the world, it seemed highly significant that a majority of us are sensory extroverts like my practical wife, living life as it comes, and only 1% intuitive introverts like myself, really concerned about the future.

This real human issue does not appear on the Critical Realist agenda, nor indeed on anyone else's, apart from a few counsellors and personnel managers. I am arguing that it should, and will try to give an explanatory outline.

Thirdly, I have walked into a Critical Realist argument that economists are going wrong because they see themselves as scientists, but are modelling their procedures on a false conception of science. I totally agree, and think the argument very important, but from the perspective of my own studies of philosophy of science[26] and practical experience of physics and information science,[27] I don't believe the academic Bhaskar/Lawson view of social science is quite right either. For a start it does not take account of the strengths and weaknesses of scientists and hence the necessity for complementary roles within science. This will ground my discussion of "real science".

Fourthly, then, I come down to my real concern, an economic system that could persuade an American President to give power supplies, for New York City business, *priority* over global warming which could make the whole Earth uninhabitable[28]. Though capitalist organisation is on the whole very logical, its first problem is that it has evolved rather than been designed, like some "spaghetti" computer programs I inherited in the 1970's, which though functionally correct were unmaintainable until thoroughly re-organised. A second problem is its using Hume's (ie Aristotle's) logic rather than the scientific specification logic of Algol 68[29], so that context and simple third level ambiguities remain unnoticed, with disastrous consequences. A third problem is that we are stuck with our history, at least for a long while.

As an engineer I remain hopeful. A rather junior French engineer, André Chapelon, took a poorly performing steam locomotive and doubled its effectiveness with really quite minor changes[30]. He took the trouble just to *look* at the reality and think through the fundamentals of what he was doing. That, ultimately, is what I believe we must do.

## CONFRONTING HUME

### Background

Let me say at once that my criticism is not of Hume but of what he taught. He was a man of his time, informed by Bacon and Newton, reacting on the one hand to the loose philosophy of Locke (critic of Descartes) and the strange one of Berkeley, and on his other theme (his atheist morality) to the savagery of religion in a Scotland of the puritan Covenant. Cardwell, discussing eighteenth century steam, set the scene thus.

> "According to Francis Bacon there are two different types of invention; there are those which, like the mariner's compass and firearms, depend on some sort of prior scientific knowledge; and there are those which, like the printing press, are substantially independent of science. Nowadays we could, of course, extend the lists enormously, adding radar, television, synthetic dyestuffs, plastics etc., to the first two inventions, and barbed wire, zip fasteners, bicycles, sewing-machines etc., to the third".[31]

The examples show that only in the second type can one *see* how the inventions work, so we can adopt as a working definition of *science* that it is concerned with making evident what cannot be seen. The information processing of the brain is thus surely a matter for science.

In 1744 Hume was "unsuccessful candidate for the Chair of Ethics and *Pneumatic Philosophy* at Edinburgh". [Italics mine].[32] Was this Hume likening thought to the invisible wind, trying to envisage effects, motion abstracted from things, what we now call process? Or was this a still Christian university envisaging the workings of Love, the Spirit of God? (For 'spirit' means breath). Certainly, much that is scientifically evident now was not evident then, and conversely with religion.

What, then, motivated Hume's arguments against causality? In the background are Newton's overturning of Aristotle's assumption that continuous movement has to be continuously caused. (In space there is no friction). In the distant background are Plato's belief in "eternal ideas" which our spirits already have, ready for "education" draw them out, and Aristotle's more physical view that knowledge, "science", is acquired, given "training" to go and look for it. The rationalist philosophy of Descartes had been Platonic, Locke's rejoinder an update on Aristotelian training, and the brilliant Bishop Berkeley, realising Locke's theory could lead to a godless evolutionism, had "irrefutably"

relocated Plato's eternal ideas in the mind of God. Echoes of all these themes may be found in Hume, but his arguments, focussed as they eventually are on "first causes", seem less a misunderstanding of Newton than a rejection of Berkeley's theology. Hume had a personal need to justify his own [at the time dangerous] rejection of God as "first cause", his admitted atheism.[33]

This said, his denial that we can know anything beyond our own experience undermines a correspondence theory of truth, and led ultimately to the belief that truth and morality are redundant[34].

Cause effecting transformation

Since Einstein we have become accustomed to the idea of the inter-changeability of matter and energy and the principle (consistent with observation) of the conservation of energy. Hume had not that advantage, so he was not able to distinguish between "things" (matter, energy in specific static forms) and "something" (energy, form unspecified, having the dynamic quality of the wind which blows where it will). Thus his argument is a "black box" argument. A "cause" is input, and an "effect" is output, but we can't need to know what is in the box, because in it you can see "nothing". Of course you can't, for what you are looking at is not a "thing" in Hume's sense but "the wind", a transfer of energy.

So here we have a different concept, not of one billiard ball causing another to move but proximity enabling momentum from the moving ball to be transferred to the static one. We have not a "thing" but a process with a beginning (object[s] carrying energy), a middle (transfer of energy) and an end (a reproduction of the situation of objects carrying energy). It is not the static object which produces the effect, it is the transfer or redistribution of energy.

But now we can have *systems* of causes, for transfers of energy are *directional* and can be reversed. The earth's momentum causes it to fly away from the sun, but that is countered by gravitational attraction, so the earth stays indefinitely in orbit. Are there then just two things in this picture, the earth and the sun? If the existence of a thing is defined in Hume's way as the persistence of the evidence for it, then the earth in orbit round the sun and the orbit itself are also "things". There are both physical and directional (information) aspects to reality. Otherwise there are no atoms.

There is no room for change in a two-process system, only simple reversal. But add another process and both change and persistence become possible. Even in a three-body system, though orbits persist their precise location becomes unpredictable: "the wind blows where it likes". *Quarks* in physics[35] and *attractors* in chaos theory[36] shed other lights on this. The difficulty for Hume's atheism is that the Christian understanding of God is of just such an eternally persisting trinity. Where he says "An object that exists absolutely without any cause is certainly not its own cause", we have a system of interactions where its existence, its persistence in that particular form, just is in fact brought about by its having that particular form, the circuital or metaphorically circular form (for three points uniquely define a circle) which makes possible both continual reproduction and variation. The physics and mathematics of this require two forces at right angles (eg the centrifugal and centripetal forces holding the earth in orbit) and two dimensions at right angles: complex numbers. Making the application of these *variable* involves a third element, language, to index or pinpoint (with Chesterton) the specific forces or quantity involved.

What this abstract discussion boils down to is that you cannot at once have the observed conservation of energy and change with nothing before the observed Big Bang; either the energy of the universe is transformed cyclically or it is derived from a larger universe (God) in which that is the case. And it is not the energy of the universe that is at issue, for that is given. What signifies is its variability and [circuital] form, and from that, the significance of language and complex numbers..

Modern Physics[37]

Let us start then with the Big Bang, and reconstruct our understanding of Hume's experience. We now detect electromagnetic waves pointing back to the explosion. Like waves in the sea, these are caused by asymmetry: the empty space in front of the wave-front and the energy behind it trying to get out: piling up, falling and pushing down, creating an alethic version of Fourier's cyclic representation of [energy] numbers[38]. We observe that north/south poles of magnets attract each other, and likewise positive/negative forms of electricity, ie the peaks and troughs of the waves. Thus if in the turbulence of the Big Bang the wave is bent round upon itself, the peak will adhere to the trough and the energy will start chasing its own tail. We have "spray", an electron, the simplest subatomic article, effectively a superconducting current with (by convention) a negative effect still showing. But we observe that a circulating current creates a magnetic field, so if (still within the immense turbulence of the Big Bang) an electron is bent round upon itself, its own magnetism will adhere to itself, entraining a much greater

amount of energy with (by our convention) the positive electrical effect now outside. But the lower-energy negative particle will adhere to the larger energy positive particle to form a hydrogen atom. Atoms can be crushed to form neutrons or combined to form larger atoms and molecules, forces due to individual particles will begin to be dominated by residual (not quite self-cancelling) forces increasing with sheer mass, and the whole panorama of physics opens up before us. This is of course theory, and not necessarily fact, but it does reasonably *fit* the facts Hume was unaware of.

Two implications follow before we reconsider Hume's deductions from billiard balls. First, the mass which is Hume's body is not only affected by energy from outside, it *is* energy in specific, stably circulating or orbiting forms, with a certain amount of variability representing free energy. Second, the key to its stability is not the amount of energy but its *form*, so we can envisage learning not as inscribed by transfers of energy but as involving *a transfer of form*, about which information science has new things to say.

The Sensory Barrier

Quite simply, what Hume had not considered is that the human body, like a radio set, has its own internal power supplies, and (without needing already to know the particular form of incoming energy), can adjust its own form to match that of the incoming signal. One can actually watch the iris of the eye adjust itself to a bright or dimming light. We focus. We turn our heads. The nerves of the eye turn individually, like daisies turning towards the sun or radio direction finders seeking maximum signal at right angles to the wavefront, experiencing to the best of their capability the energy of the wavefront, but by that time doing so with its form already known, its meaning re-encoded in a different language, ie in terms of the adjustments necessary to receive it. What we remember is not what we see, but how to see it (and what to do with what we have seen). That is why we can also recall it – faintly, empowered only by appropriate energy components from the Fourier spectrum of background noise.

Deriving an 'ought' from an 'is'.

With the mind treated as a "black box", leaving Hume only his experience of sensations and feelings, it is hardly surprising that his theories attribute knowledge to the one and the direction of our actions to the other. He was of course quite right that we will not cooperate with others unless we learn to sympathise them, but that simply evades the question of whether we ought to, leaving open the defence of unfeeling competition.

What gives a computer its specific capabilities is its programs. Minds are the equivalent of computers (a topic for another occasion), so when thinking *about* it one is also thinking *with* it. But that is only possible if one is c*apable* of thinking about it. It follows, with the sanction of functional death, that (to use the elegant modern idiom) one ought not allow a virus to corrupt one's programs.

Man needs capabilities because he lives in a context and avoids destruction of his computer hardware by adjusting to it. But man is social. There are other computers out there: the whole context reduces to the logical equivalent of another computer, which in turn adjusts itself to avoid us. If we so act as to risk destroying its hardware or software programs, it is likely to act irrationally (or we may think it will) so our own rationality may not help us to avoid it. It and we need to be able cooperate with each other to avoid mutual destruction. Therefore we ought not to destroy either its or our own hardware or programs. In fact we ought to try to improve them: to make friends of our "enemies".

Whether expressed negatively as taboos or positively in terms of love or sympathy, that is what morality is all about. The derivation is possible because computer logic, unlike Hume's Aristotelian variety, is both contextual and recursive. Once one has seen that it is logic rather than specific use of it which has the property of being true, morality is revealed as truth-*preserving* logic[39].

REAL PEOPLE

We move on to challenging the unrealistic theory of Economic Man by looking at the way in which real people function and differ. We have been considering Man as like a computer: as a unified system in which hardware, software and error-correcting logic work together. Are our differences due to hardware or software, to "nature" or "nurture"? We can already see that the answer is "both", for even with the same architecture you can have big, fast hardware and smaller, slower equipment. On the same computer one can run anything from highly functional, very efficient programs to simple, inefficient ones. Complex programs may just run inconveniently slowly on small machines.

What about error correction? The problem here is that whatever function a computer is performing all its operations need to be checked , so the checking logic needs to be both fast and

efficient. How this is achieved in electronic computers is very simple. Whereas the main logic does one thing after another, using *serial* processing, the checks are carried out at the same time as the data is processed, and all the checks which could indicate something going wrong are checked at the same time, in *parallel*. Imagine a binary number like 0100110100 represented by switches, off for 0 and on for 1. Now let each of the checks, eg for dividing by 0, result too big, location out of bounds etc, have its own switch. Quite simply, if the complete number is not 0 there is an error, the computer "smells a rat", and the main logic has to stop what it is doing and sort the problem out. The point is that the human computer seems to operate on the same principle, though the electrical circuitry is less obvious and errors are detected by means of chemical side effects. We call the serial processing *thinking***,** parallel processing *intuitive*, and the error processing which moves us to change course, *feeling*.

The role of intuition in discovery will be important for our discussion of science and is also easily explained. Recall our binary number representing error indications. When there are no problems its value is normally 0 and any other value sticks out like a sore thumb. If we have problems, however, its value is normally *not* 0, and if it becomes 0 when scanning through the options, that is an indication that we have found a solution. This is rather like tuning in a radio set until a sound is heard. (We then have to test this by listening to make sure we have found the right station).

A computer with no input and output would of course be quite useless, but even input arriving quicker than it can be processed leaves a problem.[40] Parallel processing is the answer. The brain's main parallel ports are eyes; its serial ports, ears; and two processors are provided, the left and right side of the brain, the left side tending to operate as a serial processor devoted to language and (right-handed) action, the right side as a parallel image-specialised processor used much like a high-performance maths co-processor in an up-market PC. Significantly, sight and sound usually provide the two angles needed to pinpoint meaning, but here we need only the term *sensing*.

Computers can be either stand-alone or part of a network. Humans who network a lot we will call *extroverts*, and those who are more self-sufficient *introverts*. The six terms we have used so far were those used by the great psychologist C G Jung. Two similar terms added by Isobel Briggs Myers relate to output. A computer specialised for action must check that its environment is ready before it can output, performing the function *judging*. A human who recycles his results, preferring exploration to action, is termed *perceiving.*

| Function | Preference | Abbreviation | Abbreviation | Preference |
|---|---|---|---|---|
| Networking | Extraversion | E | I | Introversion |
| Input type | Sensing | S | N | INtuition |
| Decision Method | Thinking | T | F | Feeling |
| Output type | Judging/action | J | P | Perceiving |

Table 1 Myers-Briggs Dimensions of Personality

As shown in Table 1, these terms come in pairs representing four factors or dimensions of human personality. As with right and left handedness, preferences on the left tend to indicate left brain dominance (serial processing) and those on the right, right brain dominance (parallel processing). In Myers-Briggs assessment they are each scaled from –70 through 0 to +70 and a questionnaire helps establish the balance of a person's preferences for one end or the other. Thus on the first dimension, a slightly introvert person might have a score of +5, a strongly extrovert person a score of -55. There are sixteen combinations of these preferences, not just ESTJ and INFP but as in my own case (INTJ), preferences involving both sides of the brain. In this case right brain (parallel) functions tend to dominate, with (for example) intuition setting the agenda for thinking, or feelings directing observation.

Note that both feeling and intuition are parallel-processing functions. In a computer the one would be the built-in error-correction hardware, the other a holographic image memory, switched on whole by error status (feelings) rather than selected piecemeal by language. Such a memory has first to be loaded, so that intuitives tend to be slow developers, acquiring wisdom rather than ready knowledge given suitable experience.

Table 2 below plots the personality types to draw attention to three very significant factors: differences of temperament, talent and distribution. The temperaments involve the input and decision-making characteristics SJ, SP, NT and NF, ie they represent people who see and judge things differently and tend not to understand each other. (Table 2 is like a flat map of a spherical world: bent horizontally, the SJs come together). What I call talents (as against ability, quantity of talent) are the four major groups, IS, ES, IN and EN, corresponding roughly to managerial/professional, practical/sociable, reflective/exploratory and leader/teacher types. What is most significant of all is the

distribution: a working majority in the ES group, only 4% INs, and indeed only 1% in the INTJ group, which I was told was characteristic of entrepreneurs and the only group really interested in the future!

| | | | | | |
|---|---|---|---|---|---|
| | ISTJ | ISFJ | * | INFJ | INTJ |
| | 6% | 6% | * | 1% | 1% |
| IS (talent) | | | * | | |
| | ISTP | ISFP | * | INFP | INTP |
| | 7% | 5% | * | 1% | 1% |
| | ********** | ********** | ********** | ********** | ********** NT (temperament) |
| | ESTP | ESFP | * | ENFP | ENTP |
| | 13% | 13% | * | 5% | 5% |
| | | | * | | |
| | ESTJ | ESFJ | * | ENFJ | ENTJ |
| | 13% | 13% | * | 5% | 5% |

Table 2 – (American) Distribution of Myers-Briggs Personality Types

Personal differences, I was told, join economics in Amartya Sen's "capabilities approach".[41] The eight options in Table 1 are fundamental *logical* capabilities, but "handedness" prioritises two-way communications paths to effect dominances of serial or parallel processing. Table 2 thus illustrates not just dimensional combinations but a four-way communication schema. What I want to emphasise is the logical completeness of this schema, and thus the complementary nature of the functional types, ie our differing talents *and corresponding weaknesses*.

## REAL SCIENCE

The question which immediately arises is whether all scientists are of the same personality type, and the answer, of course is, "No". Modern science is a collaborative exercise in which our peers judge our theories. Where Critical Realists tend to argue that it is about retroduction rather than deduction, and explanation rather than description, I want to argue that it is all these things and more, adding induction with what I shall call "integration"[42], and evaluation with classification. "Either/or" logic may apply to who does what, but complementary "and" logic applies to the process as a whole. Reflecting on my many years experience within a major scientific establishment, it is evident to me that all the personality types were found, normally doing those parts of the job which suited their talents.

There are two sides to this argument. For the moment I will deal briefly with the first by associating "integration" with sensing, "retroduction" with intuition, "deduction" in experimental design with thinking, and decision-making "induction" ultimately with feeling. I now want to show an association between explanatory frameworks, descriptive algorithms etc and CR's layered ontology.

Table 3 shows the familiar stratification analysis used by Critical Realists, with additional columns showing the equivalents in Aristotle, Hume and grammar. Aristotle's extremely important insight was that words ("logos") stood for things, so that inheritance relationships in the things were reflected in the words, hence "logic". Aristotle in effect conflated language and reality by using language "transparently" (though his four "causes" correspond to PID feedbacks).[43] Hume inverted this. He conflated language and reality by using constant event conjunctions transparently, failing to recognise both their alethic linguistic function and the real significance of conventional language.

| Aristotle | | Hume | Critical Realist | | English Grammar |
|---|---|---|---|---|---|
| | (Causes) | | | | |
| Language | Efficient | Thingy events | Empirical | (Observation) | Noun |
| (Things) | Formal | (Language) | Actual | (Description) | Adjective |
| | Material | | Deep structures | (Explanation) | Adverb |
| (Is a) | Final | (Goes with) | (and processes) | | Verb (be, do) |

Table 3 – Historical stratifications of reality

What I want to assert is a similar conflation of two "deep" elements in the earlier Critical Realist analysis, which has separated out in Bhaskar's *Dialectic* and in the computing and control logic around which my own work has revolved. These are illustrated in Table 4.

| Bhaskar (*Dialectic*) | Algol-68 (Frege's *Sense and Reference*) | PID Control (Heaviside's electric circuit theory) |
|---|---|---|
| 1M – Timeless | Data values (No REF) | Command signal (No feedback) |
| 2E – Biography | Variables (REF) | Proportional (Negative feedback) |
| 3L – Totality | Interpret Mode (REF REF) | Integral (Historical feedback) |
| 4D – Agency | Software/Hardware logic (REF REF REF) | Differential (Anticipating f/back) |

Table 4 – Complex four level logical stratifications

The term 'complex' here (cf complex number) means 2-dimensional. Bhaskar's account, which I have here shown very simply, has in *Dialectic* a rich, almost poetic texture which is wonderful to reflect on but would go over the heads of most people, the 76% sensory majority. The advantages of computer programming and electronics are that one can see what is happening and play with them. That I believe to be very important if practical people are to be enabled to understand the corresponding dynamics of economics, and hence the weaknesses and opportunities in that system. Put another way, my argument is that logic in this tangible, modern form ought to be (as of old) part of general education (3L) rather than just academic interest (2E) or specialist training (4D). The difficulty, of course, is that this has not been part of the education of the current generation of educators.

Before briefly discussing education we need to recap on how this argument is progressing. Map the four strata of Table 4 onto the four points of the compass as follows: 1M => N, 2E => S, 3L => W and 4D => E. Strata 1 / 2 are then represented by the N/S axis and strata 3 / 4 by W-E, with Truth (or the Arrow of Time)[44] corresponding to the direction true North - this representing where we are going to, not where we have come from. As in Bhaskar[45] there are three poles which are *not* true, and to the fourth we have only a pointer. The Cartesian coordinates and pointer together form an Argand diagram, the polar form of a complex number in mathematics. This reverses the Humean convention as to which dimension is 'real' and which 'imaginary'. (Only in imagination can things be separated from their contexts). If truth is mapped to number as in computers, ie T => 1, then true north is equivalent to the complex number (0,1), meaning "No discernable error, computes true". With this understood, it can be seen that Table 5 represents the argument so far (and where it is going) in terms of the 'vertical' and 'horizontal' components of what I call Complex Truth[46].

| | Serial ('imaginary') | Parallel ('real') |
|---|---|---|
| Humean man | Sensation | Feeling => subjective morality |
| Real people | Left-brain | Right-brain => "sacred" logic morality[47] |
| Real science | (Scientific practice) | (Technology => error correcting logic) |
| (Real economics) | (Economics as is) | (Economics as may be => self-correcting) |
| | --- | --- |
| Abstract Truth | Local to objective | Inclusive of context (Alethic truth) |
| Model | Logic/Algol68 | Computer logic/PID servomechanism |

Table 5 – The Two Dimensions of Complex Truth

I cannot fully defend these insights here, but I can illustrate them. Wiener's choice of the name *Cybernetics* for his "control by feedback" principle in 1948 illustrates the one-dimensional "vertical" thinking still so characteristic of theoretical scientists. The word means Steersman; but in real life a ship journeys through a context. Winds and currents make it drift increasingly off course, other ships and unforeseen obstacles may require it to change course. In other words steering by P-feedback is not enough; the Captain must from time to time use I-feedback from his sextant or satellite system to correct his course, and D-feedback from his lookout to avoid catastrophes. Nor does he simply follow the compass pointer to the North pole: navigational freedom derives from the fact that he can offset or "normalise" the compass to turn it into a signpost to anywhere. Nor does this information system actually steer the ship: it is a control system for steering the steering-gear, what is technically a *servomechanism*. Electronic technologists realised this about 1968. Other scientists probably didn't. Philosophers and economists have certainly not explored its implications.

PID feedbacks occur in parallel. In a timesharing computer with Von Neumann architecture, their processing can occur *virtually* in parallel, although in fact processes are in series, with just the fundamental D-detection capabilities in parallel. Suitably indexed, one computer can "go anywhere" from playing tunes to enabling an Admiral to steer a thousand ships (much like a modern railway signalman). The offset which can turn a computer into a servomechanism is the separation of theory from practice. A computer program is a theory of how to do what you want to do, this having to be translated into computer states, which are used to reset computer switches like a signalman switching points in railway lines. What made the amazing multi-flexibility of modern computers possible was the incorporation of indexing into the programming logic. Algol60 had two-level Aristotelian logic. Algol68, interpreting Russell's Theory of Types as Fregeian reference levels, found itself with four levels, the fourth pointing only to a bit of program but the third level being an index entry or (as it is called in the American language 'C') a pointer. Central in subsequent relational database technique has been a process of normalisation which ensures that all necessary indexes are in place. Work with pointers soon teaches you that "sign-post" truth is not the Tarskian either/or of 1936. To check your bank-balance it is not enough that you can select the right account: the account needs to be up-to-date.

We shall see that in economics, parallel markets now provide PID functions, while money provides the detailed flexibility. Science, and the spelling out of the basis of future education in science, are by contrast necessarily serial processes. Children (including future scientists) move from seeing to understanding to articulate skill to (if they are lucky) choosing a career reflecting which they are best at. I argue that the infant science did likewise (going from exploratory classification to active experimentation to relativistic cosmology to Shannon's mechanistic anticipation of errors), while mature science finds work for all the talents.

Understanding cannot be seen, however, and in both education and science a Humean philosophy has reinforced the naïve scientific tendency to conflate it with skill at deductive inference and articulating knowledge. The choice of conventions, the multi-sense thinking of intuition, and in science the corresponding retroduction to explanation, though all continue to occur, remain unobserved, misunderstood and devalued by the sensory majority of educators and philosophers. Educational practice will have to change before any widespread change will occur in science and economics. Critical Realism's increased articulation of understanding seems to be a necessary condition for moving from the "Big is Best" of sensory America to a sufficient understanding of why "Small is Beautiful".

Table 6 suggests how the relevant cyclic and multi-level concepts might be introduced to children (and their teachers) through information technology. The progression is from sensing to understanding to knowing to life choice.

| Primary<br>(What? => Why?) | Secondary<br>(Why? => How?) | Tertiary<br>How?=>when/where/who? |
|---|---|---|
| "3Rs" and computers,<br>group/solo,co-op/compete,<br>solve/cyclic games/models,<br>naming/classing/indexing,<br>personality types in stories.<br>PCs used to extend views/<br>make processes tangible, eg<br>show comp'nd interest grow. | Parallel studies of basic grammar<br>and typed computing languages.<br>History and re-enactment of maths<br>and science, using Roman/Arabic<br>numerals, Greek/Cartesian geometry,<br>logarithmic/Fourier transformations,<br>class/differential/cyclic system logics, and knowledge<br>programming from m/code to Pascal. | Parallel studies of maths/<br>computing/communication<br>and personality principles,<br>comparative study of roles<br>in specialisms, start of<br>professional rigour in skills |

Table 6 – Proposals for modernising structure of education

My own first-hand experience of physical and information science, combined with my studies of the history and philosophies of science and mathematics, led to my arguments that the science of our species has followed the same pattern of development as we individuals, and that science has to and does find specialisation and tasks suited to every type of person. Since Thatcher, unfortunately, the public perception of science has been directed not to its intuitive Newtons, Einsteins and Shannons but to naïve scientific "sixth-formers": ambitious and "bossy" managerial types at the interface with exploitative technology. Real science is not like that. It is a world of students, problem-solvers, experimenters and organisers who want to be left alone to work together as a team, but have to put up with outsiders (administrators and financiers) insistent on dead-lines and value-for money. Its aims are not just either knowledge or explanation, but a combination of personal interests in knowledge,

understanding, know-how and application. Studious Aristotelian classification of knowledge was directed by Bacon to experimental know-how, this 'imaginary' dimension of the truth being where Humeans have stuck. Kant's critiques began the unravelling of retroduction,[48], and scientists like myself do indeed have explanation as their goal. Science overall, however, is a process, not a goal, and the 'real' dimension is completed as it translates into action, in the "judging" function on the look-out for problems, the quality control phase of science.

The choice is between moving on to application or continuing with perception. It is the moral choice (using relative probabilities as a tool) between *accepting* the risks of application, *continuing* the costly process of testing, or somehow *narrowing* the problem down so that applications can be tentatively developed at the same time as more basic research continues. From my own observation and in my experience this overlapping of phases of development is what usually happens. There is a gradual transition from research through development to assured design[49], from concept to "concept car" to "next year's model". Experimental embodiments of explanations gradually evolve into useful and reliable systems[50], basic research becomes ever more specialised, the sheer amount of knowledge and paperwork becomes overwhelming, and the team leader who can sell the results gets promoted…

Though expressed in the language of Humean Logical Positivism, Popper's version of science comes close to this[51]. Lawson is quite right to emphasise that retroduction, the unexplained production of Popper's hypothesis, rather than deduction, the design of Popper's crucial experiments, is the key to understanding science, especially in social science where experimentation is difficult. Popper's own emphasis was the openness to criticism, to the decision process, though he did not go on to show how the decisions developed. His later "three worlds" position gets close to my own distinctions between data classes, program classes and their cross-indexing, all being present in real-world communications.

In his *Dialectic*, Roy Bhaskar buries, within masses of detail, DREIC and RREIC models of theoretical and applied science[52] which are only trivially different from what I am saying. I would extend the significance of Lakatos to practice[53], and disagree about Roy's concept of openness. Science as I know it is open in the same sense as a computer: because it takes in fresh ideas from observation and other researchers *as well as* recycling residual problems handed down by previous researchers. Its logic is closed, but circulates *problems* on which observers and students can hang their discoveries.

## REAL ECONOMICS

I want finally to initiate consideration of practical economics as a PID servomechanism, with its roots in information rather than physical science. Let us begin by re-interpreting its history.

We designate an Economics 0 as simple exchange, trading on both sides with what we can see. Economics 1uses money, so that one party can see what is on offer, the other only has a promise of redemption to a similar value. It becomes a matter for experiment as to whether the promise is kept, whether one gets "value for money". Economics 2 adds an integral. Buy capital goods and you don't have to produce yourself, the goods keep coming and money for selling them adds up. Economics 3 adds on the differential (which changes things when problems arise). Now one sells shares in the capital goods as well as the things they produce; but if they are not producing the shares will not sell and it is time to buy (and make) something else. All sounds very logical – without trading in money…

Since the days of E1 the root snag has been not trusting the promises. The situation appeared to revert to E0 if money comprised physical goods which were scarce, everyone found desirable and which therefore could be relied on for future exchange. For ease of transportation it had to be durable and compact. Gold in standard weights was the best bet for large-scale long-distance trading, while silver was available for shorter distances and bronze locally. This failed: cheats just adulterated and shaved the metal. Another problem arose from the scarcity of gold, exacerbated by usury. Until the South American conquests there was never enough for both government functions and the potential rate of trade.

When machines began to expand the possibilities of trade, a solution was found in banks holding most of the gold, with promissory notes issued for trading, these being exchanged for gold if necessary, eg for international trading. The banks could now get away with holding only enough gold for the *usual* demand, but defaulted when more was needed. (It had to become a legal requirement that a certain proportion of gold was actually kept). Under capitalist E2 money really did build up or integrate, so its scarcity meant that few had it. The solutions adopted were more usury and keeping down prices, this forcing rural craft workers into urban employment at low wages. Now ambiguity

crept into the system, because the sensory majority couldn't actually see whether falling sales were due to undesirable goods or lack of money. What they could see was their own system and the possibilities of more work ("sweating") or lower wages. Again, law had eventually to be invoked to control sweating.

More inventive minds came up with E3. Shares in large-scale capital investments, those promises of future accumulation, not only sold and promoted undertakings, they spread wealth and facilitated disinvestment. The snag shifted again. Share trading lacked safeguards, obscured problems and generated economic doctrines suppressing consciences: Perfect Rationality (belied by observation and Jungian psychology) and Necessary Competition (where *price* competition was *actual* but not *necessary*). Marx's proposals for abolishing shares and controlling trade and investment did not work. Keynes *sufficiently* realised that broken promises can be made good, we can print money as needed, but since monetary economics is just a servomechanism, we cannot evade political responsibility.

Study of economics as a servomechanism begins with Irving Fisher's MV=PT[54] being equivalent to Ohm's Law, V = I/R (Voltage = Current/Resistance), if M is normalised by dividing money in by money out (M =1 with interest rate zero), and Resistance is inverted (Conductance = 1/R). Electricity is not, as people usually think, power, but merely a carrier of power and information. Is not the circulation of promissory notes (or as it largely is now, electronic information between banks) exactly the same?[55] One does not keep electricity scarce (conductors form a sink); nor does one extract from the circulation any commission or interest, since that would make it so. One cannot extract more information than its symbols can carry[56].

High voltages are dangerous, so that efficient high voltage transmission has to be logically isolated from domestic users, with fragile uses even physically isolated by using batteries. Can a similar case be made for multiple currencies?[57] Thinking of Keynes's "liquidity preference", easy electrical paths also "short-circuit" functional ones. Is this what is happening in financial trading?[58]

There are already more questions than I can answer here, before starting on personality, methodology and power factors.

It seems to me that information scientists have the tools necessary to design an economic servomechanism combining money's facilitation of choice with "electronic" information (about what needs to be and is being *done*, each at national, local and personal levels). Economic organisation can be informed by the key electronic techniques of time-sharing and multiplexed communication.

Two big questions. Will the concept of a *sink* show how Ruskin's separation of Citizen's Income (the curate's stipend in *Unto This Last*)[59] from Motivation (provided for by *The Crown of Wild Olive*)[60] might actually work? (Under law, surely we ought to be held trustworthy unless proven otherwise)? And was Keynes right to think ahead to when Capitalism has done its job of making possible the satisfaction of physical need?[61] (Should we now be "dethroning Trader Man"[62] and glorifying social efficiency, reduction of physical waste and the maintenance and enjoyment of our planet)?

## CONCLUSION

In this paper I have had to leave out, for simplicity, much that I wanted to say about Complex Truth, the Logic of Morality, Flow Logic, Indexical Language, the Brain and Consciousness, the Art of creating Sustainable Natural Cycles, and innumerable Great People "on whose shoulders I stand". I hope I have been able to convey two consistent messages: that science has moved on since the days of David Hume, but that to lay his ghost in economics we have got to replace it in the popular understanding with an uncomplicated but dynamic understanding of the science built into today's technology. This I have sketched in a Bhaskarian schema, as realised in PID servomechanisms, Algol68 computing, Myers-Briggs personality types and (imperfectly) in Capitalist economics.

The *image* I would like you to reflect on is not one of four strata, but more dynamically, Leavitt's Diamond[63], a communication system in which four points each communicate both ways with all the others. Or "round" that into a *compass*, complete with True north, normalised course and moving pointer. Or see this Chesterton's way: Carpenter's Truth, Truths which set you Free, Decision Time at the Crossroads.[64] Christ on the Cross, opening His arms to the Four Winds, to the Ends of the Earth and all its People, with apologetic Theory on one side and arrogant Practice on the other.[65]

NOTES AND REFERENCES

[1] Began with the English Cardinal Manning's inspiration of Leo XIII's *Rerum Novarum*, 1892, and celebrated in John Paul II's *Centesimus Annus*, 1992. Available through CTS (Catholic Truth Society).

[2] *The Chesterton Review*, XXV:3 (Aug 99), p.357. Versatile Catholic philosopher G K Chesterton, a humorous but trenchant social critic, led the "green" Distributist League between the world wars. A GKC Society *Sane Economy* project is named for *The Outline of Sanity* of 1926, year of Britain's General Strike. *Orthodoxy*, cit (9), as much social philosophy as religion, was described by Peter Milward, a Professor of English, as "without any doubt the greatest work of English literature in the twentieth century" (op cit, VII:4 (Nov 81), p.354 (347-355)). GKC has inspired not only myself but, for example, the present Pope, Ghandi, science writer Martin Gardner and the celebrated economist E F Schumacher.

[3] Adam Smith, *Inquiry into the Nature and Causes of TheWealth of Nations*, 1776, 1827, Ward Locke.
[4] Hence Shakespeare's *The Merchant of Venice*, Chesterton's *The Return of Don Quixote*.
[5] My version of p.11-14 of Tony Lawson's *Economics and Reality*, 1997, Routledge,
[6] See under 'Information Science' in *Encyclopaedia Brittanica*, edition 15, 1998, vol 6 p.312.
[7] Cf. J Passmore, *A Hundred Years of Philosophy*, 1968, Penguin, p.354-5.
[8] S R Ranganathan, *The Colon Classification*, 1965, Rutgers University Press, NJ, USA.
[9] G K Chesterton, *Orthodoxy*, 1908, Fontana edn 1963.
[10] Roy Bhaskar, *Dialectic: the Pulse of Freedom*, 1993, Verso.
[11] My own interest was stirred in the 1960's by Chesterton and Ranganathan, with conclusions forming during work with the Algol68 "scientific" computer programming language. See P M Woodward and S G Bond, *Algol 68-R User's Guide*, 1972, 2nd edn 1974, HMSO.
[12] G K Chesterton, *G.F.Watts*, 1904, 1975, Duckworth, p.49.
[13] K E Boulding, *The Image: Knowledge In Life and Society*, 1956, 1961, Ann Arbor Paperback.
[14] For an extra-ordinary confirmation of this see D Williams, *Autism: an inside-out approach*, 1996, Jessica Kingsley. Donna, badly autistic herself, overcame meaning-blindness and meaning-deafness by learning to translate what she sees and hears into tactile finger-language!
[15] D J Taylor, *Dialectic and Ontology in CR and Computer Logic*, in *Alethia* 3:2 (Nov 00), IACR.
[16] A Giddens, *The Third Way: the Renewal of Social Democracy*, 1998, Polity, pp.148-9.
[17] Henry George invented the game 'Monopoly' as a simulation for his students.
[18] C E Shannon, *A Mathematical Theory of Communication*, Bell System Technical Journal, July 1948.
[19] N Weiner, *Cybernetics*, 1948, Wiley.
[20] P M Woodward and S G Bond, op cit (11) and *Guide to Algol 68 for users of RS systems*, 1983, Edward Arnold.
[21] B Russell, *Principles of Mathematics*, 1903, Routledge edn 1992, see intro. Is the class of all classes a member of itself? (The question arose in respect of Frege's logic, *Sense and Reference*). If a barber shaves all and only those who do not shave themselves, who shaves the barber? Algol-68 incorporates Frege's distinction to reveal Bhaskar's four levels of reference, with the third level, effectively an index, being of a different logical type to variables at the second level, data values at the first and procedural logic at the fourth. The distinct logical rules for indexing are what made possible the amazing flexibility or openness of modern general purpose computing. Russell's solution of treating propositions involving classes of all classes as meaningless in effect introduced multi-valued truth and made clear the possibility of different types of logic, much as non-Euclidian geometry had transformed mathematics. For a survey see R Turner, *Logics for Artificial Intelligence*, 1984, Ellis Horwood/Wiley.

[22] PID is an acronym for Proportional, Integral, Differential. This is a special case (for ensembles taken as a whole) of the Algol-68 logic. These are three logically different types of feedback, with the fourth level being the control signal, ie the command. Cybernetics originally envisaged only Proportional feedback, ie control as in steering a ship by compass. In reality, the captain has to reset his course occasionally to compensate for accumulated (integrated) drift in the past, and to post a lookout for other ships, icebergs etc, which might require a change (difference) of course in the future.

[23] For an amusing lay introduction to this see E T Bell, *The Development of Mathematics*, 1945, McGraw-Hill, pp. 413-5. The highly significant point arising from Heaviside's theory is that electrical

circuits can be built up with just three types of component corresponding to the PID functions (ie resistors, inductors and capacitors), plus transducers producing or modifying electrical signals in response to physical phenomena of whatever type, eg mechanically driven generators, thermistors (temperature-sensitive resistors), frequency-sensitive capacitors, microphones (pressure-sensitive resistors, inductors or capacitors) etc. Arguably, monetary economics reduces likewise to circulation involving consumers, investors and producers, interfacing at each point with reality. (For context, its past and its future have to be accounted for as well as present monetary incomes).

[24] What I call Heaviside logic is usually known as analogue logic to distinguish it from the digital variety. Claude Shannon articulated the principle that electrical switching circuits can be used to represent and indeed perform the standard logical functions in *A Symbolic Analysis of Relay Switching Circuits*, Dec 1938, Trans American IEE, Vol 57, p.713. In Critical Realist terminology this amounts to *alethic* logic. In analogue systems the switching off by feedbacks is gradual rather than abrupt. In computer hardware the number 1 might be represented by the *presence* of an electrical voltage, in analogue systems by eg an actual voltage, the position of clock hands, radio waves, or a Fourier spectrum able to uniquely identify things as minutely complicated as genetic codes (note (38)).

[25] C G Jung, *Psychological Types*, 1921, Collected Edition Vol 6, 1971, Routledge. For Myers-Briggs, see eg M Goldsmith and M Wharton, *Knowing Me, Knowing You*, 1993, SPCK; for a different Jungian perspective, T and N Guzzie, *About Men and Women*, 1986, Paulist Press; also J O'Connor and I McDermott, *Principles of NLP*, 1996, Thorsons, and from pathology, Williams, op cit (14).

[26] Courses in British Empiricists 1957-8, Popper/Kuhn/Lakatos period 1976-8. Most influential of many authors have been N R Hanson, *Patterns of Discovery*, 1958, Cambridge, A N Whitehead on many topics, and I Lakatos, op cit (50).

[27] In or around Britain's Radar Research Establishment (RRE), by now DERA, with a wider remit.

[28] News, c. 3rd April 2001.

[29] I was told when Algol-68R came into use in 1971 that the language had originally been designed for specifying scientific procedures, but RRE had written a compiler so it could be used for computing.

[30] H C B Rogers, *Chapelon: genius of French steam*, 1972, Ian Allen.

[31] D S L Cardwell, *Steam Power in the Eighteenth Century*, 1963, Sheed and Ward.

[32] Details from D Hume,*A Treatise of Human Nature*, Book 1, 1739, 1962, Fontana, p.375-6.

[33] D Hume, *An Inquiry Concerning Human Understanding*, 1748, Bobs-Merril edn 1955, NY, p.172-180. On p.173 Hume contradicts himself by wanting to ground theology in faith, not evidence, accepting no doubt the testimony of his friends but ignoring at once the first-hand testimony of early Christians, comparatively testable history in their accounts, Pascal's Wager, and St Paul's early acknowledgement that "Unless Christ be risen from the dead, our faith is in vain".

[34] Cf. F R Ramsey's "redundancy" theory of truth, and Neitzschze's "will to nothingness".

[35] J Gleick, G*enius: Richard Feynman and Modern Physics*, 1992, Little Brown, pp.390-6.

[36] J Gleick, *Chaos: making a new science*, 1987, Cardinal edn 1988, Sphere Books, pp.121-152,232-40.

[37] Though these crudely simplified theories are my own, cf. A M Young, *The Reflexive Universe*, 1976, Anodos Foundation. (Substantial overviews available at www.arthuryoung.com).

[38] Fourier's transform uses the identity $1 = (\sin^2 a + \cos^2 a)$ where a can be $2\pi ft$ (f is wave frequency).

[39] Cf Shannon, op cit (18), and the widespread use of error-correcting logic in information technology.

[40] Relative value derives from this. The best control system uses all the *available* feedbacks.

[41] I Robeyns, *An Unworkable Idea or a Promising Alternative? Sen's Capabilities Approach Examined*, Nov 2000. [Cambridge CR Workshop 14 May 2001].

[42] Cf. H C Metcalf and L Urwick, ed, *Dynamic Administration: the Collected Papers of Mary Parker Follett*, 1941, Pitman, ch.1, *Constructive Conflict*, pp.30-49.

[43] Cf note (22) with A Flew, *A Dictionary of Philosophy*, 1979, Pan, p.54 (a Humean account).

[44] Cf. A Eddington, *The Nature of the Physical World*, 1928, Everyman ed. 1935, esp. pp. 52,76-7.

[45] Op cit (10), ch.2. Cf. P Hamilton, *Thank God for Absense*, Alethia Vol 2 No 2 (Nov 2000), p.52-3.

[46] Third-level concept (from complex number) devised 1986. Cf. first-level work at Santa Fe Institute: M M Waldrop, *Complexity: the Emerging Science at the Edge of Order and Chaos*, 1992, Penguin.

[47] 'Sacred' in the sense of "not to be violated" (with interesting overtones).

[48] As named by C Peirce and ably illustrated by N R Hanson, op cit (26).

[49] T S McLeod, *The Management of Research, Development and Design in Industry*, 1969, Gower.

[50] I Lakatos, *The Methodology of Scientific Research Programmes*, in I Lakatos, ed, *Criticism and the Growth of Knowledge*, 1970, Cambridge.

[51] K R Popper, *The Logic of Scientific Discovery*, 1935, English edn 1959, Hutchinson.

[52] Op cit (10) pp. 69, 109, 133. Incredibly, these terms are not in the abbreviations, index and glossary.
[53] Op cit (50).
[54] D E Moggridge, *Keynes*, 1976, Fontana, p.48.
[55] J Robertson, *Transforming Economic Life: A Millenial Challenge*, 1998, Green Books/Schumacher Society/New Economics Foundation, p.54.
[56] The Fundamental Theorem of Information Science, see Shannon, op cit (18).
[57] Ibid (55), p.55.
[58] Report that 95% of trade is currently financial, ibid, p. 53, cf. Giddens, op cit (16).
[59] J Ruskin, *Unto This Last*, 1862, 1911, George Allen, p.37. (In 1860, was suppressed)!
[60] J Ruskin, *The Crown of Wild Olive*, 1866, 1908, Dent (Everyman).
[61] Op cit (54) pp.96, 107.
[62] V A Demant, *Christian Strategy*, in W E Temple et al, *Malvern 1941*, Longmans, pp. 137-42,147.
[63] Named for social psychologist F R Leavitt.
[64] Cf. *Orthodoxy*, "orthogonal". Op. cit (9), eg p.100: "there are an infinity of angles at which one falls, only one at which one stands". Carpenter's Truth (Christ being a carpenter) is an upright.
[65] The Bible, Lk 23:33-43.