REVIEW ARTICLE

THE DEATHBED CONVERSION OF A SCIENTIFIC SAINT

REVIEW OF "FOUNDATIONS AND METHODS FROM MATHEMATICS TO NEUROSCIENCE: ESSAYS INSPIRED BY PATRICK SUPPES"

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> "Knowledge comes through likeness. And so because the soul may know everything, it is never at rest until it comes to the original idea, in which all things are one. And there it comes to rest in God."
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> Sermon 9 by Meister Eckhart, as translated in *The Reading and Preaching of the Scriptures in the Worship of the Christian Church* (1999) by Hughes Oliphant Old, Ch. 9 : 'The German Mystics', p. 449 Grand Rapids, Michigan: Wm. B. Eerdmans.

1. INTRODUCTION: A 21ST CENTURY WITTGENSTEIN?

There is no attempt here to claim Pat Suppes for theism; while a "cradle catholic", in that his mother, like this author, was of western Ireland (specifically, O'Brien and

Costello) lineage, Pat was an atheist whose Catholicism ended, if not at his baptism, then with the death of his biological mother during his childhood. Nevertheless, the quote from Eckhart above, itself echoing St. Augustine, is meet for this questing, generous spirit.

This writer dares to embark on a review of the Suppes opus only because Pat has passed away and there will be no further radical re-structuring of what turned out to be dogmatic slumbers. It is worth noting that, in person, Pat was a civil, humorous man who loved company. When he chose also to be convivial, he was a generous and gracious host who did what truly great hosts do – he made people of all ages feel delighted with themselves, and with the occasion just attended, to the point of not noticing the expertise of their host.

It makes it even more extraordinary that the work is perhaps the most austere and formidable philosophical-scientific achievement of the past century. But for quack radiation treatment as far back as the 1930's – for acne! – Pat, a force of nature if ever there was one, might have expected to continue productive well into his second century.

While Pat's earlier work on economics, psychology and the philosophy of science achieved justified world renown, it is the sustained attack on problems of mind and world that occupied his later energies. This book is a Festschrift, from Hintikka to Fenstad to his friend, the Nobel laureate Ken Arrow. The later might agree with me that Pat's brilliance as an administrator – he had over 200 working under him at one point – and multidisciplinary gifts is what prevented him from achieving the ultimate distinction of a Nobel Prize to accompany by 1990 National medal for Science.

This review will follow the book in dividing Pat's work into separate categories. While Pat himself responded – from his deathbed, as events turned out – there is much more than can be said to which this review is a humble contribution. There is a separate volume on his anticipation of MOOCS and successful educational business career that should itself be the subject of more attention (Suppes, 2013).

The book begins with a foreword by the co-editor Longino and an overview by Michael Friedman. The latter in particular is engaged with Suppes as a philosopher of science. Some background is necessary; in particular the relationship between Suppes and Carnap needs to be unpacked. It will be argued here that Suppes ended by resembling Carnap's nemesis Wittgenstein – a name oddly mentioned only once in this volume – more than he might have cared to admit.

The Vienna circle thrived in the teens of the 20th century; around the time of Pat's service in WW2   the pincer attacks by Gödel and the later Wittgenstein began to wreak havoc in what had been a formidable intellectual edifice. That edifice was constructed on painstaking analysis of language, including the language used to

express scientific theories, as the royal road to understanding the relationship between mind and world. Carnap exemplified this new linguistic philosophy; to simplify, theories were to be expressed as a set of "protocol sentences" in which all the terms would have a clear semantic denotation.

The early Wittgenstein brought this argument to its apotheosis. What existed were "states of affairs" (Sachverhalten); these could be analysed into atomic facts (Tatsachen). Language was, in deeply encoded form, a set of pictorial representations; the task of the scientist was to analyse sentences into atomic propositions and map these logical atoms onto atomic facts. This mapping, argued the early (Tractatus) Wittgenstein could be done by a "private language" idiosyncratic to each person as the instruction set is idiosyncratic to each microprocessor. It will not have escaped the attentive reader that this is essentially the programme of 20th century GOFAI; please see my 2003 book.

Wittgenstein later recanted these views, and began a phase that looks frankly nihilistic; better put, he became a philosophical "edifier" rather in the style of Suppes' late Stanford colleague Rorty. There could not exist such private languages, argues the later (Investigations) Wittgenstein; we can only consider language in the context of encompassing life-situations called "language games" Indeed, if we fail to acknowledge this, we might end in the absurdity of asking questions like "What is a question?"

It is this fatal self-reference that Gödel's formalist, and perhaps stronger, arguments take as their target. While Wittgenstein, the emigrant aeronautics engineer who (unlike Pat) spurned his family's wealth, was at best a tangent to the Vienna circle, Gödel was intrinsic to its program. Thus, when he produced a convincing demonstration that systems of a power $>=$ standard arithmetic were either provably consistent or fit for purpose (never both), the shock was deep. This underlies also Turing's response to Hilbert's Entscheidungsproblem, a proof that there exists no universal computational procedure, and arguably a leitmotif for 21st century research on consciousness.

Pat argued for a set-theoretic view of scientific structures; the 2002 book considered by many to be his masterpiece extends this paradigm to the many fields we will visit in this review. It is fair to say that he had backed away from this optimism by the time of his passing.

He is often perceived as backing a "semantic" set-theoretic view over Carnap's "formal languages" view. As Friedman points out in his overview, this is simplistic; as Longino points out, use of scientific constructs in new contexts, like harmonic oscillators in neuroscience, is viewed as merely pragmatically useful. Friedman is also at pains to distinguish the more sophisticated Suppesian epistemology from the

minimalism of Carnap's Tractatus-like "correspondence" theory; for Suppes, representational structures are to mediate between mind and world, and be grounded in measurement . All of these concepts are unpacked in the book.

It is in the role of mathematics that we see the most dramatic instabilities in the later Suppes. For him, there really is no longer philosophy of science distinct from science itself, nor can science really be divorced from mathematics. A consequence of that is the lack of distinction between pure and applied mathematics.

Suppes is inconsistent on these points, even in this volume; his commentary on Falmagne (261-2) shows skepticism about whether the rather baroque formalisms used have any denotation. In fact, the skepticism reaches creationist heights that will be pointed out in this review of an enjoyable and important volume

2. FOUNDATIONS OF MATHEMATICS

The book proper starts with a rather weak paper called "What numbers are" by Fenstad. Weak, because while there is an attempt at a debunking of Wigner's "unreasonable effectiveness of math", it is clear that neither Suppes nor Fenstad has given any serious consideration to the genetic epistemology of Piaget and his followers like Bruner.

While Suppes claims there is no mystery about how often abstract math refers – and, as we have seen, he vacillates about its applicability to the real world – Piaget led a sustained attack on this issue. Unquestionably, lower animals like birds can "subitize", apparently counting well into the double digits, but Piaget insists that this cardination ability does not get synthesized with the capacity to seriate before "conservation" status is achieved in human children at about 7 years and with it true number emerges for the first time in nature. That may be controversial; what is not to be questioned is that Piaget asked the right question as to how the logical necessity of math can emerge from the contingent facts of experience.

Jaakko Hintikka continues with a paper – less baroque than rococo - claiming that there is no axiom of choice; it would have been better to see his work on synthesizing the two Wittgenstein periods here. Finally, even Pat throws up his hands in incomprehension at Harvey Friedman's paper.

3. PHILOSOPHY OF SCIENCE

The book gets going with this section and Rykman's well-written and erudite paper called "The Structure, the whole structure". It is absurd to suggest that Carnap is syntactic, and Suppes' set theory semantic; formal languages correspond at each level in the Chomsky hierarchy to various set generators. Indeed, a suitably restricted

context allows syntax, without semantics, to curtail distributional freedom. In fact, the new Suppes looks like a proponent of language games.

Paul Humphreys continues with "Models of data and inverse methods" He invokes Napoletani in arguing that "Big data" may allow us to leave theory behind. As of now, that simply is not happening; while data-driven approaches will solve deterministic problems like speech to text, they have failed miserably with gene expression and other such problems.

We can quickly pass over de la Sierra's economics paper, as the great Ken Arrow takes the risk of writing a straightforward economics paper; see below. Stephan Hartmann with "Imprecise probabilities" correctly suggests non-classical probability regimes may work for QM.

4. MATHEMATICAL REPRESENTATION

Duncan Luce, who passed in 2012, invokes "Holder's theorem" in the context of measurement. It is conceivable that this line of thought is effectively dead; so also for Falmagne's "Meaningful, permutable laws" which, as we have seen, caused even Suppes to question whether pure math always has denotation and a link to science. Sandwiched between the two is a little gem from Ken Arrow called "The economic system as trade in information". One does not need a moral argument for capitalism, argues Arrow; it is simply the case that allowing price to be subject to the market is the most efficient way of disseminating information. Arrow alludes to the early experiment is socialism, which expected an iterative series of corrections to price-setting by the government, as failed. Remarkably, he sees professions like medicine as essentially justified by the fact M.D's have information; in the imminent era of near 100% smartphone penetration, professions may no longer be allowed conspire against the public.

Finally, Leitgeb's "Belief as qualitative probability" provides a salutary corrective to the current mania for quantitative Bayesian nets. It is here, that fugitive transition between the subjective and objective, that Suppes so brilliantly defends the chink in his armor.

5. LANGUAGE, MIND, AND LEARNING THEORY

For Piaget (see my 2003, 2014 books), logical certainty arises because the organism internalizes interactions first carried out at the boundary of subject and object. There is nothing like this in the Suppes oeuvre; there is, however, an adaptation of Shannon in Skyrms "Learning to signal".

While categorically not a genetic epistemologist, Pat was an innovative and thorough developmental linguist. Levelt's "From Rousseau to Suppes" looks at Pat's

excellent corpora, and the prescient development of probabilistic parsers so wrongly maligned by Chomsky.

Neither was Pat a phenomenologist; Follesdal's daringly titled "Suppes and Husserl" has little to say about links between the two. What we get instead is a limpid analysis of Husserl's notion of "Noesis", roughly speaking the neural hypotheses lined up at any given moment (called "preafference" by Walter Freeman – see our 2014 collection), and the "noema", constraints on the object. Pat's response is that of a confused friend; what is left out is that the "perpetual beginner in phenomenology" that Husserl admitted himself to be admitted defeat in this project. Pat's emphasis on Aristotle might have benefited from the modified realism of his erstwhile colleague Karl Pribram – see my 2014 monograph

6. NEUROSCIENCE

Like his fellow-American Frank Lloyd Wright, Pat Suppes experienced a breathtaking burst of creativity in the ninth decade of his life. This work, which is being continued at Stanford, features the highly technical competent researchers in this section bringing a wide artillery of techniques to bear on issues of mind, brain, cognition, and epistemology. It is their work which will indicate whether what was being hinted at in Pat's autumn years until his passing in late 2014 is an entirely new language for describing humanity's relationship to reality itself. There are precedents other than FLW; Michelangelo's final pieta anticipated the elongated bodies of el Greco and tropes from modern sculpture; Beethoven's Op 130 anticipates the rhythmic innovations of "Le sacre du printemps" as its author Stravinsky was happy to admit

De Barros and Oas begin this section with "response slection using neural phase oscillators". In my 2014 book, this inheritance of the harmonic oscillator model from the "merely physical" realm is inevitable; for Longino in the introduction, we have seen caveats. De Barros and Oas follow researchers like Izhekevich in stressing the emergent property of synchronization is networks of oscillators. They may exceed their remit in arguing, contra 55 years of cognitive science, that stimulus-response structures work for language; nevertheless, the hints at quantum cognition, with or without a Hilbert space formalism, make this an exciting paper.

Visitors to Ventura hall since 2000 often found themselves with electrodes attached to their scalp for long period, In this context, Carvaelhes argues that non-invasive neuroscience is better done with the electric field than potential. There are exciting results; along with "Bad math", the use of diverging infinite sequences in QM, Pat also coined the term "extreme statistics"

Why "extreme statistics"? Well, the alternative is highly invasive surgery, such as that done by Edward Chang at UCSF. Consequently, there is a moral impulse

underlying the cleaning up of the signal in Perreau-Guimaraes' "Similarity pairs derived from pairwise classifications". With some justification, pat argued that words are first represented as auditory patterns and that we can recognize them. Invasive researchers like Bob Knight of UC Berkeley scorn this approach. Pat, with whom we will leave the last word, is very careful not to over-claim for these results.

Colleen Crangle finishes this section with a paper called "Representation, isomorphism and invariance". This is a leap into the big blue; an attempt to find semantic templates in the brain using resources like wordnet. Pat makes it clear that he is skeptical that Colleen and he found these. Given that Knight's invasive work has so far found just phonic data, that is not surprising.

7. SCIENCE IN PRACTICE

Fagot-Largeault's "The psychiatrist's dilemma" is perhaps the weakest paper in the collection. It is included, perhaps, because Pat was about to initiate work on EEG monitoring of couples' dialog. While the tension between drug therapy and talk therapy, between genetic and psychodynamic causes, is well-made, there is little there there (unlike ironically 2015 buzzing Oakland!).

Beth Loftus gives a charming account of her 1960's work with the formidable Dr Suppes in the then burgeoning field of mathematical psychology before venturing onto her later, independent work on "Illusions of memory". Essentially, uncorroborated witness statements, even when an attempt to tell the truth, are often worse than useless in court.

The final paper, on Evidence-based policy ("Where rigor matters") was, rather remarkably, funded by the Templeton foundation. Pat is correctly exercised about this; as the ex-director of science for a major Irish political party, I am very skeptical indeed.

8. THE ALTERNATIVE; REPARSING NATURE

It is my belief, expanded on in my 2014 monograph, that Pat's (2002) self-admitted failure to reduce any realm of being to another - for example, the biological to the physical –is due to the fact that ontological discontinuities have logical and computational consequences. Physics with constraints begets chemistry; naïve nanotechnology chose to ignore the effects of numerical constraints in orbitals on the type of molecules that can be created. On entering the biological realm, these numerical constraints begin to transform into syntax and semantics. Such projects as the HGP and GWAS have plateaued after ignoring these constraints, best handled in new subjects like biosemiotics. A reparse of nature involves new academic subjects,

and indeed a looser conception of the academy than with which Pat might have been familiar and comfortable.

It may be clear that I am not convinced that Pat really was interested in phenomenology, and that here he had an intellectual center of gravity in subjective probability. With that in mind, I believe that it makes sense also to speak of a discontinuity in nature on entering the intentional realm. This realm is constrained by the requirement that, unlike simple covariance of the signal between environment and organism earlier in evolution, the intentional subject has a formal system >= standard arithmetic.

At this point I wish to speculate. All our senses evince a mystery of transduction and an exquisite sensitivity that invite a QM explanation. Husserl, the "perpetual beginner in phenomenology", was onto a massive insight that first became incarnate in the frame problem in AI. Moreover, Aristotle simply will not do for perception. I speculate; while Bell's inequalities invite the concept of an entangled nexus at the physical level, immanence and universality of biological forma cannot really be explained by "convergent evolution", a simple non-engagement with the issue. Intentional creatures like us participate in a Noosphere; while Leibniz may be the closest 17th century analogue to Suppes, his duel with Newton – who in the Principia did not use the calculus he allegedly discovered – shows an immanence of Ideas that would have pleased Plato.

9. APOLOGIA, NOT APOLOGY; THE LAST TESTAMENT OF AN AMERICAN ORIGINAL

I wish finally to speak of my relationship with this great and good man. His student Alistair Isaac has felt obliged to write an apologia which is part apology. My dealings with Pat began with his endorsing two of my courses for teaching at Stanford, the second while he was recovering from yet another surgery. Ironically, given his academic conservatism, it was he who endorsed my biosemiotics course – the third in the world – for teaching at Stanford and who repeatedly took me in, almost off the street, after certain abusive experiences in Ireland (see my 2013 book) made it impossible for me to work in my home country. Finally on this topic, while engaged with gifted youth, the companion CSLI volume (Suppes, 2013) shows his compassionate and thoroughly-researched engagement with blind, deaf and mentally retarded children. For Pat the political libertarian, the champion of economic inequality, it was all about realization of human potential to a degree that the Rand Paul presidential candidacy might echo.

A now elderly Finn who worked with Pat spoke of his superb eye for talent, coupled with his insistence that the talent, once hired, stick to whatever last Pat

prescribed. That is very much consistent with being a third generation oilman; yet Pat's stentorian demands for reports, the last within a week of his death, never ended up with dismissals.

Had he stayed working for his Dad, who insisted on his starting with pick and shovel, Pat would likely have become an Okie oil billionaire. In reality, he spent the last 64 years of his life at Stanford, living on campus after his grandmother loaned him the money for his first house. The fact remains that his work is rooted in the scientific approach of his, the "great generation", with all is virtues and drawbacks.

The virtues are clear; precision, honesty, hard work. The drawbacks may be related to the fact that, unlike the present, the USA was engaged in war with a series of technologically sophisticated adversaries. It was important to try and axiomatize measurement before someone else did, to find enhancements for human performance among Americans before the Russians did so among themselves. For all its importation of scientists, the USA did not ever claim to have produced Sakharov's equal.

Pat's drive to axiomatization resembled a compulsion; his failure to succeed as his self-inflicted programme demanded resulted in what looks like a deathbed conversion to Wittgensteinian skepticism. This writer believes that conversion to be ill-motivated rather than insincere; Isaac's piece comments on Pat's (2002) dissatisfaction at failing to reduce any science to axioms. In fact, edifier as he had become, Pat regarded foundational discussion as necessary only when progress in science resulted in antinomies, like when Bell's theorems necessitated new theories of non-classical probability.

To say, as Pat does in this book, that fossils are too far in the past for us to induce any certainty, means for many of us that he simply had set the bar too high. The skeptical argument that scientific theory is vastly under-determined by data goes back at least to David Hume. The converse problem – the deluge of neuroscientific data that Pat believes will drown the reminder of this century – is troubling only for those who hope for a set of atomic facts.

Once one leaves the academy, which Pat did rather too rarely, definitions of "knowledge" and "certainty" emerge from folk psychology which in the right hands, may lead to a complete reparse of nature. This I achieve to some extent in my 2014 book; its first insight is that truth changes its stripes at the perimeter of campus. Skeptical arguments by Gödel and others acquire traction, until the world of platonic objects and free will that Gödel and his colleagues like Von Neumann envisaged now seem the rule, rather than a mere technical objection, later to be dispensed with

Hundreds of $ billions are currently being spent each year on doomed, ill-conceived research projects. This money has largely become a perverse incentive; there is more research money to be had through sticking to an outdated paradigm and continuing to write about its incremental success than actually solving the problem. Google recently solved the "speech to text with no prior training" problem; had they not done so, billions more would have been wasted on "more fundamental" approaches.

In neuroscience, Obama's brain project is headed by Christof Koch; a C+H article (see my 2014 edited collection here; my paper with Tom Doris is the one in question) we wrote in 2014 was sent to him along with an offer to share the data. It proves Koch's "Phi" notion is wrong; however, there is so ouch money sloshing around that Koch is free, a la the Queen of Tarts, to define "neuron" and "information" as he wills. Along with Google, Suppes never made this error.

Conversely, had Pat lived what seemed to all of us to be his allotted five score and ten, there would right now be an undergraduate with the elements of a new technique gravitating toward him.. By 2020, Pat would have formalized the technique, papers would be published in genuinely good journals, and the cycle would continue. I suspect that much of the funding for this type of work, as with the centers he funded at Stanford, came from Pat's own pocket

Those who did not know him can skip the forbidding American English syntax of his main oeuvre for the moment; his commentaries on each of these papers are recognizably Pat, the friend and mentor , and a real American original. You will enjoy your new friendship with this truly great man.

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