Wolpert, Chaitin and Wittgenstein on impossibility, incompleteness, the liar paradox, theism, the limits of computation, a non-quantum mechanical uncertainty principle and the universe as computer—the ultimate theorem in Turing Machine Theory

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ABSTRACT

I have read many recent discussions of the limits of computation and the universe as computer, hoping to find some comments on the amazing work of polymath physicist and decision theorist David Wolpert but have not found a single citation and so I present this very brief summary. Wolpert proved some stunning impossibility or incompleteness theorems (1992 to 2008-see arxiv.org) on the limits to inference (computation) that are so general they are independent of the device doing the computation, and even independent of the laws of physics, so they apply across computers, physics, and human behavior. They make use of Cantor's diagonalization, the liar paradox and worldlines to provide what may be the ultimate theorem in Turing Machine Theory, and seemingly provide insights into impossibility, incompleteness, the limits of computation,and the universe as computer, in all possible universes and all beings or mechanisms, generating, among other things,a non- quantum mechanical uncertainty principle and a proof of monotheism. There are obvious connections to the classic work of Chaitin, Solomonoff, Komolgarov and Wittgenstein and to the notion that no program (and thus no device) can generate a sequence (or device) with greater complexity than it possesses. One might say this body of work implies atheism since there cannot be any entity more complex than the physical universe and from the Wittgensteinian viewpoint, 'more complex' is meaningless (has no conditions of satisfaction, i.e., truth-maker or test). Even a 'God' (i.e., a 'device' with limitless time/space and energy) cannot determine whether a given 'number' is 'random' nor can find a certain way to show that a given 'formula', 'theorem' or 'sentence' or 'device' (all these being complex language games) is part of a particular 'system'.

Those wishing a comprehensive up to date framework for human behavior from the modern two systems view may consult my article The Logical Structure of Philosophy, Psychology, Mind and Language as Revealed in Wittgenstein and Searle 59p(2016). For all my articles on Wittgenstein and Searle see my e-book 'The Logical Structure of Philosophy, Psychology, Mind and Language in Wittgenstein and Searle 367p (2016). Those interested in all my writings in their most recent versions may consult my e-book Philosophy, Human Nature and the Collapse of Civilization - Articles and Reviews 2006-2016 662p (2016).

I have read many recent discussions of the limits of computation and the universe as computer, hoping to find some comments on the amazing work of polymath physicist and decision theorist David Wolpert but have not found a single citation and so I present this very brief abstract. Wolpert proved some stunning impossibility or incompletenesstheorems (1992 to 2008-see arxiv.org) on the limits to inference (computation) that are so general they are independent of the device doing the computation, and even independent of the laws of physics, so they apply across computers, physics, and human behavior, which he summarized thusly: "One cannot build a physical computer that can be assured of correctly processing information faster than the universe does. The results also mean that there cannot exist an infallible, general-purpose observation apparatus, and that there cannot be an infallible, general-purpose control apparatus. These results do not rely on systems that are infinite, and/or non-classical, and/or obey chaotic dynamics. They also hold even if one uses an infinitely fast, infinitely dense computer, with computational powers greater than that of a Turing Machine." He also published what seems to be the first serious work on team or collective intelligence (COIN) which he says puts this subject on a sound scientific footing. Although he has published various versions of these over two decades in some of the most prestigious peer reviewed physics journals (e.g., Physica D 237: 257-81(2008)) as well as in NASA journals and has gotten news items in major science journals, few seem to have noticed and I have looked in dozens of recent books on physics, math,decision theory and computation without finding a reference.

It is most unfortunate that almost nobody is aware of Wolpert, since his work can be seen as the ultimate extension of computing, thinking, inference, incompleteness, and undecidability, which he achieves (like many proofs in Turing machine theory) by extending the liar paradox and Cantors diagonalization to include all possible universes and all beings or mechanisms and thus may be seen as the last word not only on computation, but on cosmology or even deities. He achieves this extreme generality by partitioning the inferring universe using worldlines (i.e., in terms of what it does and not how it does it) so that his mathematical proofs are independent of any particular physical laws or computational structures in establishing the physical limits of inference for past, present and future and all possible calculation, observation and control. He notes that even in a classical universe Laplace was wrong about being able to perfectly predict the future (or even perfectly depict the past or present) and that his impossibility results can be viewed as a "non-quantum mechanical uncertainty principle"(i.e., there cannot be an infallible observation or control device). Any universal physical device must be infinite, it can only be so at one moment in time, and no reality can have more than one (the "monotheism theorem"). Since space and time do not appear in the definition, the device can even be the entire universe across all time. It can be viewed as a physical analog of incompleteness with two inference devices rather than one self-referential device. As he says, "either the Hamiltonian of our universe proscribes a certain type of computation, or prediction complexity is unique (unlike algorithmic information complexity) in that there is one and only one version of it that can be applicable throughout our universe." Another way to say this is that one cannot have two physical inference devices (computers) both capable of being asked arbitrary questions about the output of the other, or that the universe cannot contain a computer to which one can pose any arbitrary computational task, or that for any pair of physical inference engines, there are always binary valued questions about the state of the universe that cannot even be posed to at least one of them. One cannot build a computer that can predict an arbitrary future condition of a physical system before it occurs, even if the condition is from a restricted set of tasks that can be posed to it—that is, it cannot process information (though this is a vexed phrase as many including John Searle and Rupert Read note) faster than the universe. The computer and the arbitrary physical system it is computing do not have to be physically coupled and it holds regardless of the laws of physics, chaos, quantum mechanics, causality or light cones and even for an infinite speed of light. The inference device does not have to be spatially localized but can be nonlocal dynamical processes occurring across the entire universe. He is well aware that this puts the speculations of Wolfram, Landauer, Fredkin, Lloyd etc., concerning the universe as computer or the limits of "information processing", in a new light (though the indices of their writings make no reference to him and another remarkable omission is that none of the above are mentioned by Yanofsky in his recent comprehensive book 'The Outer Limits of Reason' (see my review). Wolpert says he shows that 'the universe' cannot contain an inference device that can 'process information' as fast as it can, and since he shows you cannot have a perfect memory nor perfect control, its past, present or future state can never be perfectly or completely depicted, characterized, known or copied. He also proved that no combination of computers with error correcting codes can overcome these limitations. Wolpert also notes the critical importance of the observer ("the liar") and this connects us to the familiar conundrums of physics, math and language. As noted in my other articles I think that definitive comments on many relevant issues here (completeness, certainty, the nature of computation etc.) were made long ago by Ludwig Wittgenstein and here is one relevant comment of Juliet Floyd on Wittgenstein: "He is articulating in other words a generalized *form* of diagonalization. The argument is thus generally applicable, not only to decimal expansions, but to any purported listing or rule-governed expression of them; it does not rely on any particular notational device or preferred spatialarrangements of signs. In that sense, Wittgenstein's argument appeals to no picture and it is not essentially diagrammatical or representational, though it may be diagrammed and insofaras it is a *logical* argument, its logic may be represented formally). Like Turing's arguments, it is free of a direct tie to any particular formalism. Unlike Turing's arguments, it explicitly invokes the notion of a language-game and applies to (and presupposes) an everyday conception of the notions of *rules* and of the *humans who follow them*. Every line in the diagonal presentation above is conceived as an instruction or command, analogous to an order given to a human being..." The parallels to Wolpert are obvious.

However once again note that "infinite", "compute", "information" etc., only have meaning (i.e., are transitive (Wittgenstein) or have COS--Conditions of Satisfaction (Searle) in specific human contexts—that is, as Searle has emphasized, they are all observer relative or ascribed vs intrinsically intentional. The universe apart from our psychology is neither finite nor infinite and cannot compute nor process anything. Only in our language games do our laptop or the universe compute.

However not everyone is oblivious to Wolpert. Well known econometricians Koppl and Rosser in their famous 2002 paper "All that I have to say has already crossed your mind" give three theorems on the limits to rationality, prediction and control in economics. The first uses Wolpert's theorem on the limits to computability to show some logical limits to forecasting the future. Wolpert notes that it can be viewed as the physical analog of Godel's incompleteness theorem and K and R say that their variant can be viewed as its social science analog, though Wolpert is well aware of the social implications. Since Godel's theorems are corollaries of Chaitin's theorem showing algorithmic randomness (incompleteness) throughout math (which is just another of our symbolic systems), it seems inescapable that thinking (behavior) is full of impossible, random or incomplete statements and situations. Since we can view each of these domains as symbolic systems evolved by chance to make our psychology work, perhaps it should be regarded as unsurprising that they are not "complete". For math, Chaitin says this 'randomness' (again a group of Language Games in Wittgenstein's terms) shows there are limitless theorems that are true but unprovable—i.e., true for no reason. One should then be able to say that there are limitless statements that make perfect "grammatical" sense that do not describe actual situations attainable in that domain. I suggest these puzzles go away if one considers W's views. He wrote many notes on the issue of Godel's Theorems, and the whole of his work concerns the plasticity, "incompleteness" and extreme context sensitivity of language, math and logic, and the recent papers of Rodych, Floyd and Berto are the best introduction I know of to W's remarks on the foundations of mathematics and so to philosophy.

K and R 's second theorem shows possible nonconvergence for Bayesian (probabilistic) forecasting in infinite-dimensional space. The third shows the impossibility of a computer perfectly forecasting an economy with agents knowing its forecasting program. The astute will notice that these theorems can be seen as versions of the liar paradox, and the fact that we are caught in impossibilities when we try to calculate a system that includes ourselves has been noted by Wolpert, Koppl, Rosser and others in these contexts and again we have circled back to the puzzles of physics when the observer is involved. K&R conclude "Thus, economic order is partly the product of something other than calculative rationality".

Bounded rationality is now a major field in itself, the subject of thousands of papers and hundreds of books. And this seemingly abstruse work of Wolpert's may have implications for all rationality. Of course one must keep in mind that (as Wittgenstein noted) math and logic are all syntax and no semantics and they have nothing to tell us until connected to our life by language (i.e., by psychology) and so it is easy to do this in ways that are useful (meaningful or having COS) or not (no clear COS). Finally, one might say that many of Wolpert's comments are restatements of the idea that no program (and thus no device) can generate a sequence (or device) with greater complexity than it possesses. . There are obvious connections to the classic work of Chaitin, Solomonoff, Komolgarov and Wittgenstein and to the notion that no program (and thus no device) can generate a sequence (or device) with greater complexity than it possesses. One might say this body of work implies atheism since there cannot be any entity more complex than the physical universe and from the Wittgensteinian viewpoint, 'more complex' is meaningless (has no conditions of satisfaction, i.e., truth-maker or test). Even a 'God' (i.e., a 'device' with limitless time/space and energy) cannot determine whether a given 'number' is 'random' nor can find a certain way to show that a given 'formula', 'theorem' or 'sentence' or 'device' (all these being complex language games) is part of a particular 'system'.