COMPLEXITY THEORY: THE SIMPLE ANSWER TO ALL OUR PROBLEMS

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COMPLEXITY THEORY & CHAOS

➤ This absurd example is a metaphor for the existence of magic solutions to problems, and also reflects the connection commonly made between complexity theory and chaos

➤ But complexity theory is about bringing *order* to our understanding of complex systems

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THE LATEST FASHION

➤ Complexity theory is the latest fashion in defence analysis, following catastrophe theory, fuzzy sets, chaos etc

➤ If it's so promising, then we need to know more about it, but if we must also have at least some confidence that research money spent on it will not be wasted

➤ However, the evidence to provide this confidence is pretty thin in the defence analysis area

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THE VIEWPOINT OF THIS PRESENTATION

➤ My gripe is *not* with complexity theory as such, but with its application to defence analysis

➤ In fact, of the various papers and books consulted for this presentation, the best, Kauffman's excellent "At Home in the Universe", contains much innovative and impressive material, mostly applicable to biological areas

EMERGENT BEHAVIOUR I

- The fact that complex high-level behaviour *can* arise from simple low-level rules does not necessarily mean that:
  - Any particular instance of real complex high-level behaviour *must* in fact have arisen from simple low-level rules; or that
  - Simple low-level rules can be found which will generate any given form of complex high-level behaviour; or even that
  - If some specific real complex high-level behaviour does *in fact* arise from simple low-level rules, it will be possible to deduce what these rules are (cf trapdoor encryption algorithms)
- A much richer range of complex high-level behaviours must clearly be possible from *complex low-level rules and interactions*, which occur abundantly in systems involving human beings
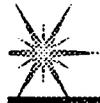
EMERGENT BEHAVIOUR II

- The hope seems to be that, rather as in thermodynamics, the same high-level behaviour emerges to a great extent *regardless* of the detailed nature of low-level interactions
- However, this remains to be proved: both thermodynamics and the systems so far studied by complexity theorists are actually governed by much simpler rules than those which apply to military systems
- We already know that Lanchester equations represent only a very crude approximation to real combat
- The validity of any specific variety of high-level behaviour must be backed up by a causal model or a proof (cf statistical mechanics), and preferably historical data as well: an act of faith is not sufficient
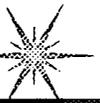
REAL COMPLEXITY IN CONFLICT

- Conflict is very messy, with many interactions in which most effects have a large random component, and for which simple rules are very unlikely to be a sufficient explanation
- In simulation we try to get away with as simple low-level rules as possible, but they still end up being pretty complex
- The idea that simple rules will nevertheless be sufficient to replicate any specific form of complex behaviour is pretty incredible
- The idea that one of a small set of simple rules "will do" in order to generate any required high-level behaviour is even more incredible
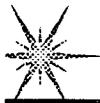
COMPLEXITY THEORY AS SCIENCE

- Qualitative understanding of system behaviour is not sufficient: quantitative prediction and control, consistent with historical data, are required if analysis is to be useful
- Kauffman doesn't seem to offer much hope from the point of view of prediction and control. There's a definite fatalistic element in what he has to say, in that complex systems have decentralised "minds of their own" which are specifically resistant to control
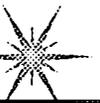
COMPLEXITY THEORY AS A NEW FIELD

- It is too easy to make a name in a new field
- Before long, really hard work will be required to make significant progress, at which point I suspect there will be a mysterious migration to another fashionable topic
- By analogy with catastrophe theory, for example, it would be very useful to have a topological theorem identifying all possible types of interaction between different classes of command agent. This would be a great achievement, but it would be very difficult, and even if it were achieved, it is not clear how mainstream defence analysis would be affected

WHAT SHOULD A NEW ANALYTICAL CRAZE LOOK LIKE?

- It should have a catchy title
- It should be quite difficult to understand
- It should contain an element of truth
- It should promise a (magic) solution to many of our problems.
- It should be revolutionary:
  - It needs to be new and different
  - It must sweep away all existing approaches
  - However, this is also a major weakness, since not only does it fail to take advantage of previous work, but it implies significant change

WHAT WILL BE THE NEXT CRAZE TO HIT US?

How about *"Perplexity* Theory"?

MACINTOSH QUOTES I: SERIOUS MISUNDERSTANDINGS

- Classical "ideal maths" is irrelevant, because it has been "dealt massive blows" by Gödel, Turing and Chaitin
- "Information cannot be valued for quantity but only quality..."
- "Humans...make computationally undecidable decisions...everyday..."

MACINTOSH QUOTES II: THE GLORIOUSLY MEANINGLESS

- "Yet, if confidence is not to be grossly misplaced, this cannot be what Poincaré called analytically blind nor merely compromise systems further with what Van Creveld diagnosed as 'Information Pathologies', largely through a lack of critical scrutiny."
- "It is global markets that are making asymmetry far more innovative than those unencumbered by state procurement chains and risk assessment."
- "In summary, the ESA sweeps up systemic threats or 'threats without enemies', in terms of globalised instabilities shared across sustainable yet fragile ecologies and economies but not merely INFOSEC as IT infrastructure."
- "Thereafter, connectivity is folding space into multiple dimensions that change relations from distant to proximal very rapidly"
- "However, if semiotics in Reflexive Control excuses massive rule bases to capture situation awareness, it will radically miss the point, commanding no influence metaphorically or otherwise"

MYSTICISM & MODERN SCIENCE/PSEUDOSCIENCE

- "The central issue we confront today is to reinvent the sacred" (Kauffman p4)
- Innocuous end of the spectrum:
  - Overenthusiastic PR?
  - Comprehensible metaphors?
  - Appreciation of the beauty of simple laws?
- Worst end: emergent behaviour = magic
- Middle: new psychological crutch to replace religion
- "It is better not to know, than to know and to be wrong" (Feynman)

COMPLEXITY THEORY AND THE RESEARCH FUND-HOLDER

- Clarke's Law: Sufficiently advanced science is indistinguishable from magic
- Gresham's Law: Bad OR forces out good OR
- Most research fund-holders in this sort of area are scientists themselves: they should remember their roots, and avoid being conned by glib salesmanship

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CONCLUSIONS

- Complexity theory *is* innovative and impressive in improving our understanding of certain very complex systems
- *But* its application to defence analysis has been vastly oversold: it is unlikely to provide much more than a qualitative sidelight on military affairs
- There *is* a need to remain open-minded and to encourage lateral thinking, but this should be tempered in responsible research fund-holders by up-to-date knowledge, an incisive ability to separate the sheep from the goats, and a willingness to terminate research programs if and when they exhaust initial promise