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**When physical
systems realize
computation?**

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Overview

- Computational explanations as mechanistic
- Criteria of ascribing computations:
 - ◇ Epistemic
 - ◇ Mechanistic
 - ◇ Code correspondence

Do physical and biological systems compute?



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Computational Explanations

- Computational Explanations are a kind of mechanistic explanations: how a mechanism realizes a function?
 - ◇ Explanations involve specifying the component parts and the interactions between them (Cummins, Bechtel, Craver)
 - ◇ Computational processes are not different from any other mathematically specifiable processes

Computational Explanations

- According to Searle & Putnam, computational properties are conventional but it makes all science conventional as well
- I'm arguing that computation is a natural kind
- BUT: computation and information can be ascribed to objects of any scale and size, like fundamental physical properties

Explicating Computation...

- Is all information processing computation? (What about analog computation?)
- What about hyper-Turing computation?
 - ◇ These are mostly verbal problems

Epistemic Criteria

- Explanatory and predictive value
 - ◇ More E&P value than purely mechanistic/functional explanation in causal terms (Occam's Razor)
- Constant and coherent ascriptions
- Simplicity and parsimony

Mechanistic Criteria

- Computational systems must be systems (or subsystems)
 - ◇ Frequency of interaction delineates the system
 - ◇ Systems must be relatively isolated (but open to be able to interact) and cohesive
 - ◇ Implementation of computational process in the mechanism requires supervenience over causal structure

Mechanistic criteria

- Mechanism must be identifiable on the lower level:
 - ◇ It must be a mechanism not just in virtue of computational description but of the structure of the whole system
 - ◇ There must be functional structures that implement it

Code Correspondence Criteria

- The computation must be specified in terms of code:
 - ◇ ≥ 0 output values
 - ◇ ≥ 0 input values
 - ◇ The code must match (intensionally) the causal structure of the process from start to end; the algorithm is to be specified not just in terms of I/O
 - ◇ For a general notion, it is not required that code is specified in terms of digital computation (can be analog)

Code Correspondence Criteria

- Classical digital computation: UTM-specifiable (=partial recursive functions etc.)
 - ◇ The explication should only require that code be specified in any ideal computation theory that could supersede the current one (transparent computationalism, Chrisley)
 - ◇ Representations are not required in the computational system (but not excluded!)

Test Case 1: PDP-11

- PDP-11:
 - ◇ A successful DEC minicomputer (the first one where C and Unix became popular)
 - ◇ Fulfills all criteria



Test Case 2: Searle's Wall™

- According to Searle, this wall implements WordStar™
- But criteria are not fulfilled:
 - ◇ No new prediction/explanation
 - ◇ No code actually ascribed to mechanism
 - ◇ No mechanism identified



Test Case 3: *Lavatera cretica*

- Paco Calvo 2007:
 - ◇ Do plants compute? The blunt answer is “yes”.
 - ◇ Leaf laminas of *Lavatera cretica* can not only anticipate the direction of the sunrise, but also allow for this anticipatory behavior to be retained for a number of days in the absence of solar tracking.



Conclusion

- Proposed criteria require vast knowledge about physical systems, so computational explanations in many cases will be idealizations
- It is not decidable a priori whether a physical system contains a certain mechanism: computational explanation is a tool of empirical science

Thank you!

<http://marcinmilkowski.pl>

Kazimierz Naturalise Everything Workshop:

<http://www.obf.edu.pl/>