Computers Can Do Almost Nothing – Except Cognition (Perhaps)

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1. The Classical Picture: Computational Cognition

1.1. The cognitive system (functionally)

- Computational representational theory of mind or ***computationalism:*** the human mind is a functional computational mechanism operating over representations
  - Representations caused by information-theoretical processes (Dretske, Fodor) or biological function in a “teleosemantics” (Millikan, Papineau).
- Motivation: *Machine functionalism*

  “What unites them [the cognitive creatures] is that […] they are all computing the same, or some part of the same abstract <<sensory input, prior state>, <motor output, subsequent state>> *function*.” (Churchland 2005, 333).

  ➔ *Classical Cognitive Science and AI*

1.2. Turing machine computing

Church-Turing thesis: All and only the effectively computable functions can be computed by a Turing machine – i.e. step by step, following an algorithm (definite and finite rule)

1.3. Critique of the classical picture: The mind is not a computer

- No meaning or other intentional states through computation - ‘Chinese room’, encodingism, etc.
- Embodiment (and enactment) in cognitive science
- Morphology is crucial for intelligent action
- Anti-representationalism, sub-symbolic cognition: digital items like ‘concepts’, ‘words’ or ‘phonemes’ play little or no cognitive role
- Goal-dependent cognition (no description without prescription)
- …

2. An Alternative Picture: The Computational Brain

A. Brain functionalism

- Cognitive functionalist computationalism is dead (pretty much), and so is GOFAI, so how about brain functionalism?
  - At some functional level (perhaps several), the brain operates as a digital computer (syntactically, not over representations)

    ➔ reproduce in different hardware?

[e.g. Sandberg 2013; H. Markram ‘human brain project’; Kurzweil 2013, etc.]

Ch. Koch: Biophysics of Computation (OUP 1999)

“The brain computes! This is accepted as a truism by the majority of neuroscientists engaged in discovering the principles employed in the design and operation of the nervous system.” (1) … incoming data – encoding – computational operations – control of output

“can be thought of as computation as long as it can be mapped on one or more mathematical operations that perform some useful function” (e.g. marble running down a hill computes “local minimum of two-dimensional energy function”)

… if “actually being exploited by the organism” (2) which is a biophysical question

- Assuming this is true, if we could scan the whole brain of a human and run it on a (different) Turing machine, *would it produce intelligence?*

3. Digital Computation: Three levels of description

1. Physical
2. Syntactic
3. Semantic

Result: *The Grounding Problem*

“How can the meanings of the meaningless symbol tokens, manipulated solely on the basis of their (arbitrary) shapes, be grounded in anything but other meaningless symbols?” (Harnad 1990, 335) – based on (Searle 1980)

4. Multiple Realization & Causal Powers

4.1. The same computation can be realized in several ways, in different hardware

- Digital & Algorithmic
- Possibility of multiple realization is guaranteed for Turing machines

Thesis: *If a system is not multiply realizable, then it is not computational*

4.2. Causal powers

- Given multiple realizability, would reproducing the computation reproduce the behavior? Not necessarily!
  - A computational model of an apple tree does not produce apples.
  - If one implementation produces a red light, another might produce a switch down. (The light/switch is not caused by the computation, but by the physical realization.)
  - *Hardware-dependent features are not computational* ("morphological computation" is not computation in my terminology)
- So what *would* a reproduction of the brain on a Turing machine reproduce?

5. Requirements for A Different Turing Realization

5.1. The brain is a digital computer

- A matter of neuroscientific research, not a matter of decision
- At which level? The synaptic level?
- The function of the brain/neural system must be computation

5.2. Only the syntactic level of description matters for causal powers

5.2.1. Physical level: Hardware independence

- Any embodiment thesis must be false – be it necessary or contingent
- A physical level is necessary for ‘running’ the computation – but this level is irrelevant to output (even motor output)

Note: Brain-Body dependence

a) It might be useful to make a cut-off at the brain or the central nervous system (and then look at it in terms of input-output)

b) It might also be useful to look at the entire neural system … but then emergence and bodily features will almost definitely creep in

c) It is hard to argue that the brain does what it does actually (not necessarily) independently of the body

5.2.2. Semantic level: Meaning independence

- Computing can be specified purely syntactically

So, the brain can only be reproduced on a (different) Turing machine if:

a) The brain is a digital computer (functionally understood), and

b) For its causal powers, only the syntactic level matters, not the hardware and not the semantics

[This looks hopeless.]

6. Conclusion I

6.1. Computing has no causal powers (independently of an implementation)

- Initial question: “So, if the whole brain is a computer and we could scan it and run it on a Turing machine, would it produce intelligence?” – *No.*
    - Computation alone cannot be the cause of intelligent behavior (coping, achieving aims, learning, cooperation, culture, …)
- We can formulate the gist of our discussion in a ***dilemma***: Either the system is multiply realizable or it is not. If it is, then only syntactic properties are maintained from one realization to the other. If it is not, then we need a separate argument for the view that two realizations share some property, such as intelligence.

7. Conclusion II

7.1. Purely syntactic structure may be just what is needed for cognition, i.e. information processing

- … machine translation, formal games, data-mining, search, manufacturing, … (GOFAI) *and* neural dynamics (Schöner), probabilistic approaches (A. Clark 2012)
- But: Do not fool yourself with symbols that mean something to you – but not to the machine
  - In the S. Thrun video (Scaramuzza), is the robot 'building a map', is it 'doing SLAM'? No. It is building a syntactic structure that allows *us* to use it to build a map, to interpret it as a map.
- These syntactic structures and processes are truly multiply realizable. Their causal powers depend on specific realizations, however.

8. Objections

a) What we are interested in in the brain is obviously not its causal powers as a paper-weight or whatever but its function of *information processing*, so it is trivially a computer. – Only on the dubious assumption that all information processing is computational (definitely not all is Turing-machine computational).

b) If you reduce computing to the syntactic level, your answer to the title question must trivially be negative. Information needs semantics. – OK. If we need ‘semantic computing’ then we need a cause for that semantics, i.e. we are back at square one.

c) There is no reason to restrict ourselves to a particular type of computing. – The universal Turing machine can compute anything that is digitally computable. If there is more to computing (dynamic, analog, etc.), the questions are 1) why call this computing?, and 2) do implementations on different hardware have the same (or the desired) causal properties?

d) Brain-computer interfaces and neural replacement systems show that the brain is a digital computer – No, they don't. One can replace the function of a computing system by some other system (see analog telephones); one can interface with a computing system physically and non-computationally. I am doing this right now with my notebook computer.

[…remarks on readings]