WHAT IS COGNITION IF NOT INTERACTION?

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What might cognition be if not computation? For most of the last 70 plus years since Turing's seminal paper 'Computing Machinery and Intelligence', Cognitive Scientists have been drawn to the computational model of the mind; as Hodges writes [6], "*To understand the [Turing] model of 'the brain', it was crucial to see that it regarded physics and chemistry, including all the arguments about quantum mechanics ... as essentially irrelevant. Only the logical pattern of the 'states' could really matter ... It was a materialist view of mind, but one that did not confuse logical patterns and relations with physical substances and things, as so often people did*".

Thus, in 1962 Frank Rosenblatt described connectionist approaches to Artificial Intelligence (AI) primarily in terms of 'pattern matching' tasks [10]; in contrast, and just fourteen years later, Newell and Simon repositioned the field in terms of explicit 'symbol manipulation and heuristic search' [7]. However, at the classical heart of both strands of AI, lies a tacit acceptance of Turing's fundamental computational metaphor and since few explicitly argue for this, it seems that most researchers sim ply implicitly assume computation is at the heart of cognition.

This mechanistic [Turing Machine] conception of mind effectively views thought and cognition as a ballistic process: once the chains of computation are in execution - the initial values in place and the mechanisms in motion - the outcome is fully determined. And so in embracing this ballistic model humankind's will (and place in the universe) seems concomitantly diminished.

However, over the last 60 years the philosophical doctrines underlying computationalism have been put to question. Perhaps the most well-known objections include:

Epistemological: from

(1) Dreyfus who, from a Heideggerian perspective, highlighted the difficulty of encapsulating *common sense knowledge* in computational [rule-based] systems [5];

(2) Dennett who in the *Philosophical Frame Problem* asked how machines can access relevant 'problem domain' knowledge without explicit exhaustive search [4];

(3) Penrose who, following Lucas, deployed *Godelian arguments* to show that computation cannot lie at the heart of the 'unassailable demonstrations of mathematical truth' used by human mathematicians in establishing mathematical proof [9].

Ontological: from

(4) Searle who (a) highlighted the *observer relativity* of computation and (b) infamously deployed his *Chinese room argument* to show that computations cannot give rise to genuine 'understanding'; *syntax is insufficient for semantics* [11];
(5) Bishop who deploys argument from Putnam and Searle to argue that *machine consciousness entails panpsychism* [1].

Furthermore, objections (3) .. (5)[1] (above) - superficially merely targeting GOFAI computationalism - also impact both the 'continuous dynamical systems' and 'classical connectionist' approaches to cognition [13] (including the 'Deep Learning' algorithms at the heart of the current wave of 'nouveau connectionism'); assessed together, we suggest these criticisms offer interesting reasons to question the over-arching computational hegemony.

In contrast, recent research in *Communicating and interaction systems*[2] explores an alternative metaphor for cognitive processes - based on *interacting stochastic diffusion processes* [3][3] [8] [12] - that may side-step [at least some of] these issues with computationalism. This talk will summarise recent progress towards demonstrating that communicating populations of interacting stochastic diffusion processes are also Turing complete.

References

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[1] Although it has been argued that the Frame Problem [2] also arises in a connectionist setting :- Haselager & Van Rappard (2008); Samuels (2010).

[2] Developing core findings from Templeton Project 21853: *Cognition as communication and interaction.*

[3] Winner of the 'Norbert Wiener Award' for the best paper in Kybernetes, 2005.