

Will the real artist stand up? Computational creativity as mirror to the human soul

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Abstract. This paper argues that a too-expansive view on creativity is unhelpful at best and deeply misleading at worst. As with “representation”, the word “creativity” comes value-laden in ways that researchers cannot lightly get away from, if they can escape at all; simply claiming that one is using the word in a technical sense is not a solution. Neither should one take an overly narrow view that takes advantage of *a priori* arguments to deny creativity to classes of agents or putative agents solely by their membership in those classes. The paper proceeds by offering a definition of creativity meant to prejudice neither human being nor artefact; then setting out the conditions for a putative creative agent to be a creative agent, concluding that no existing artefactual agents appear to fall into this category; finally, addressing the question of why computers, computer programs, robots, and related artefacts have nevertheless had a profound – indeed, transformational – effect on human creativity, taking creativity to places that neither human beings nor artefacts could have gone on their own. It ends with a discussion of the person I see as one of the key early voices on computational creativity.

1 What is creativity?

[Consider] an atomic pile of less than critical size: an injected idea is to correspond to a neutron entering the pile from without. Each such neutron will cause a certain disturbance which eventually dies away. If, however, the size of the pile is sufficiently increased, the disturbance caused by such an incoming neutron will very likely go on and on increasing until the whole pile is destroyed. Is there a corresponding phenomenon for minds, and is there one for machines? There does seem to be one for the human mind. The majority of them seem to be ‘sub-critical’... A smallish proportion are super-critical. An idea presented to such a mind may give rise to a whole ‘theory’ consisting of secondary, tertiary and more remote ideas... [30, p. 454].

Computational creativity: The philosophy, science and engineering of computational systems which, by taking on particular responsibilities, exhibit behaviors that unbiased observers would deem to be creative [9, p. 21].

There is a general consensus that creativity is one of the key aspects of human or human-like intelligence [32, p. 450]. That is about as far as the agreement goes, however. In particular, one finds a curious divide in the research community between

those would insist that artefactual agents could never be creative, even in principle; and those who insist that they not only can be but already are.

In the former camp I would place Lund University’s Jordan Zlatev, for whom living organisms are distinguished by their possession of intrinsic value, while certain organisms (notably enculturated human beings) distinguish themselves from others by their capacity to create meaning for themselves [34]. Artefacts – at least as they exist today – are not alive; therefore they cannot be creative; but Zlatev seems hostile to the possibility that they ever *could* be alive/creative, either. In the latter camp one finds no less a heavyweight in the computational creativity community than Maggie Boden, by whose definition of creativity² any number of virtual and physical artefacts³ – not least Harold Cohen’s AARON [7] – qualify as creative agents. The disagreement is not just or even particularly one of definition, however, but goes to the heart of what it means to be human.

Nevertheless, a working definition is required. I propose the following, which I will attempt to justify over the course of the paper:

Creativity. The at least partly – yet never fully! – intentional act of an intentional agent or agents recombining elements of past or present experience in more or less strikingly novel ways to yield insights – from the subtle to the life- or world-altering – or⁴ more immediate practical benefit.

A number of aspects of this definition require clarification:

1. **at least partly:** Unlike serendipity from which it usefully may be distinguished, creativity does not come about by accident. It cannot be the product of random chance (even though chance may play an important role); rather, it requires someone (call her the *creative agent*) trying to be creative. What this implies, too, is that it’s not just the product that counts – a common metric in computational creativity – but the process by which it is produced [8].

² “... The ability to come up with ideas or artefacts that are new, surprising, and valuable” [1]; cf. Geraint Wiggins [32, p. 451]: “the performance of tasks which, if performed by a human, would be deemed creative.”

³ ... By which I mean anything that has been artificially constructed as the product of human activity rather than coming together as the result of naturally occurring processes.

⁴ To be clear, the “or” is intended as “inclusive or”.

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2. *yet never fully! – intentional*: Neither can creativity be forced. A creative agent cannot simply decide to be creative, hence the well-known phenomenon of “writer’s block” recognizable across all areas of creative activity.
3. *act*: The act need not be limited to the “outwardly” observable: an artwork, an invention. It might be the seeking out and discovery of an idea – one that could, but need not, be shared with others. Note that acts, by their nature, are never truly instantaneous (“in the moment”); they play out over time, and where one act stops and another begins may be difficult or impossible to say.
4. *of an intentional agent or agents*: The definition sets high requirements on agency, with the explicit aim of avoiding one rule for human beings, another for artefacts. The creative agent must be the sort of agent who can operate with conscious intent.⁵ An agent lacking this capacity can certainly produce something that appears to be creative but the creativity, if any, will not be located in that agent. The requirements on creative agency will be discussed at length in Section Two. For now, note that the creative act need not be the product of a single creative agent’s actions.
5. *recombining elements of past or present experience*⁶: Like imagination, creativity does not come out of nowhere, despite occasional appearances to the contrary; in some important sense, it is never truly new (or, as Boden writes, “there’s new – and there’s new” [1]). This definition emphasizes what Boden sees as only one type of creativity (“unfamiliar combinations of familiar ideas” [1]) at the apparent expense of the other two: exploratory and transformational [2]. What Boden sees as distinct types of creativity⁷ this definition views as different aspects of a single phenomenon, aspects that may be more or less prominent depending on the circumstances but never fully absent. The exploratory aspect (“someone trying to be creative”) has already been mentioned. The recombinatory aspect, however, is in many ways the cornerstone.
6. *in more or less strikingly novel ways to yield insights – from the subtle to the life- or world-altering*: Creativity comes in degrees, both in terms of how it is viewed at the time and how it is subsequently viewed, looking back. After all, a creative act that seemed relatively unimportant at the time may later be seen to have extraordinary consequences. Consider that the true significance of Johannes Kepler’s creative improvements on Tycho Brahe’s models of the solar system were not immediately apparent even to him – yet they came to play a critical role in the establishment of Nicholas Copernicus’ model as the accepted one in science. Here is the transformational aspect of creativity at its clearest.
7. – *or more immediate practical benefit*: The definition returns, at its close, to the mundane. A newly written haiku may serve simply to lift its author from a moment of depression. A new kind of hook may serve no greater purpose than allowing one particular picture to hang on one particular wall where it could not hang before. Still, even the smallest acts of creativity have a transformative role to play.

Note what this definition does *not* address: Boden’s distinction between “psychological” (P) and “historical” (H) creativity, where P-creativity is new for the agent (or, though Boden does not seem to address this possibility explicitly, agents) doing the creative act, while H-creativity is, so far as anyone can tell, new for anyone, anywhere, at any time up till the present [2, p. 30]. Partly this is because the “so far as anyone can tell” qualification is playing a really critical role, especially if one opens up the possibility of other species on other worlds.⁸ Partly it is because Boden seems open to the creatively new, particularly of the transformational variety, that does *not* involve recombining elements of past or present experience: creativity that really does, as it were, come from “nowhere”.

It is a frequent observation that the “new” is often not so new as it appears or as people are quick to judge it. It is not quite as the writer in Jewish and Christian traditions puts it: “What has been is what will be, and what has been done is what will be done; and there is nothing new under the sun” [18, p. 805]; but even acts of creation that were not possible, in human terms at least, more than a few years or decades ago nevertheless stood on the shoulders of *other* acts of creation, the former blending into the latter in a broader arc of creative endeavor. Whereas Boden sees H-creativity as a special instance of P-creativity, I see it simply as a different perspective on the same phenomenon: one that, ironically, fails to put the creative act into its proper historical perspective and acknowledge its debt to the past. All creativity just is (individual or collective) P-creativity, in the end.

Note, too, that this definition is agnostic about the possibility (and value) of distinguishing different types of creativity, other than to resist Boden’s distinctions (and those who would build on them). Neither is its purpose to set out the different levels of creativity: what counts as less or more creative. Such matters lie beyond the scope of this paper.

The next section attempts to apply the definition, reflecting on its consequences toward determining who counts as a creative agent – concluding that (in general) humans and members of some other species do, while existing artefacts do not. Section Three then addresses the question of how and why computational creativity remains a critically important endeavour: where it came from and where, perhaps, it is going.

⁵ Alan Turing – inspiration for the final section of this paper – might be seen to be arguing against this with his rejection of what he calls the “argument from consciousness” [30, pp. 445-447] against the possibility of thinking (and, by extension, creative) discrete-state machines. Closer examination however shows that his target is solipsism and its tempting argument that “no one is conscious except me.” For Turing, what later would come to be called *philosophical zombies* are, indeed, conceivable, but uninteresting.

⁶ For an extensive discussion of the critical role of experience in creativity – albeit without a clear definition of what “experience” means – see [15].

⁷ ... Even as other researchers (e.g., Wiggins [32, p. 454]) have noted the vagueness of the boundary between them.

⁸ Of course no one – on any world, presumably – created the Mona Lisa before da Vinci did; but da Vinci created it by drawing on existing painting techniques, along with his experience of human anatomy, along with – most likely – a model posing for him.

2 Who qualifies as a creative agent?

...Creativity is not a special talent possessed only by a fortunate elite. On the contrary, it is an unavoidable aspect of normal intelligence. . . [2, p. 41].⁹

We live to believe that Man is in some subtle way superior to the rest of creation. It is best if he can be shown to be *necessarily* superior, for then there is no danger of him losing his commanding position [30, p. 444].

2.1 Consciousness required

I have said that a creative agent must – by the definition offered here – be one capable of acting with conscious intent: that is, the creative agent must, at some level, be aware of what she is doing.¹⁰ That probably rules out a range of other species (though hardly all, unless one is inclined again to *a priori* arguments and willing – as e.g. Zoltan Torey is [29, p. 90] – to discount the evidence of various species passing versions of the so-called *mirror test* [12] and evidence from corvids of creative tool construction and use: see e.g. [17]). It probably also rules out newborn human infants. Does it rule out artefactual agents like AARON? It would seem it does.

In [24], Blay Whitby and I set out to address and refute claims by a number of researchers – notably Uma Ramamurthy and Stan Franklin [27] – that their creations had achieved at least some degree of consciousness. The problem was *not* that they were artefacts; an earlier paper of ours [23] concluded that what we called the *artefactual question* was a red herring, confusing matters by suggesting that different rules might apply to “natural” and artefactual agents. *Pace* John Searle [28], it does not matter how the agent is built “inside” or even, ultimately, whether the agent’s behaviour may be seen to be guided by an explicit list of rules – only whether the agent’s behaviour is measurably different, in any relevant way, from that of any other agent to whom one would attribute conscious intelligence: i.e., a mind.¹¹ I have argued [22] that the hallmark of consciousness – as with conceptual agency (the two may be seen as two sides of a coin) – is a flexibility of behaviour in “reasoned” response to one’s environment, allowing one to take one’s past experiences into account in deciding how to respond to present circumstances¹²; while the

⁹ Another version of this passage reads, “. . . it’s an aspect of *human* intelligence in general” [1] (emphasis mine).

¹⁰ As Wiggins writes [32, p. 455]: “Self-awareness is generally cited as the property which distinguishes the artist from the craftsman.” Wiggins makes conscious awareness a requirement at least of transformational creativity, if not creativity in general. He discusses the critical role of reflection at much greater length in [33].

¹¹ This is not to say that artefactual intelligence, conscious or otherwise, can be arrived at in such a way – our stated assumption was and remains that it almost certainly can not – only that, if one *were* presented with an artefactual agent otherwise indistinguishable from an intelligent agent, one should not conclude, as Searle does, that the agent lacks a mind *just because* one “knows” it is only following a rulebook. Either it is not really doing so, despite appearances, or one’s assumptions about what makes intelligence possible require revisiting.

¹² Such a definition will, of course, be a nonstarter for those who consider consciousness epiphenomenal and those who follow Daniel Dennett [10] in seeing consciousness as a useful fiction we tell ourselves. It is, however, compatible with Thomas Nagel’s [19] “being there”; for how else does one judge whether someone

hallmark of intelligence is arguably (but non-controversially, I think) its independence from any particular domain of application. The problem with existing artefacts is that they lack that flexibility of behaviour and domain-independent reasoning. The problem with existing claims to conscious artefacts, we found, is that either the authors are reducing consciousness to some simpler value x , or they are coy about whether they are to be taken at face value or metaphorically.

An inspiration for both papers [24, 23] was Jordan Zlatev’s *Semiotic Hierarchy* [36, 35]: a prescriptive account meant to rescue researchers from trapping themselves into implicit assumptions built into the language they have coopted from everyday use. According to the Semiotic Hierarchy, language presupposes (depends upon) sign use, for it seems that language requires the prior ability to communicate. Likewise sign use presupposes a culture of shared intentionality to nurture it, while such culture presupposes some basic level of consciousness: otherwise, one has a society of David Chalmers’ philosophical zombies [4]. The intrinsically dynamic nature of consciousness – constantly adapting response to circumstances – in turn presupposes life. Each level (*life - consciousness - culture - semiosis - language*) lays the foundation for the next: a healthy antidote, we thought, to tendencies to overattribute. The definition of creativity in Section 1 is offered with a similarly prescriptive intent.

Whitby and I concluded that moral agency does *not* require linguistic ability [23, p.14]; [24, p. 3] but does require semiosis (because the moral agent needs to be able to communicate evidence of her moral agency to herself or others¹³). Similar reasoning should apply to creative agency; and, indeed, Simon Colton and Geraint Wiggins, at least, seem inclined to think that it does, with their talk of creative agents “*framing* their creative acts with information that adds value, possibly via reference to political, historical, or cultural contexts” [9, p. 25]. Nevertheless, language is not required. It seems clear that prelinguistic children of a certain age and mental development can be and are creative in limited but identifiable ways; the same applies, as mentioned earlier, to members of the corvid family. It probably applies to our nearest relatives, the great apes, at least those living in captivity [31]; and it may well apply, in varying degrees, to any number of other species. On the other hand, creative agents presumably *do* need to be able to communicate their creative intent; prelinguistic infants do so to their caregivers, crows to the fellow members of their social group. That is how the creative act is recognized and passed on.

2.2 The signature of life

Setting consciousness aside for the moment, can any existing artefacts claim to be alive? I can think of only two, and they are qualified examples, as only the genome was artefactual (still a significant accomplishment, and a transformational creative act): the recent announcement of a new form

else has that sense of “being there” – how else does one judge whether anyone is “at home” – except through observation of such behaviour?

¹³ Note that this does not require that she actually do so, only that she has the capacity to do so, given the appropriate opportunity.

of the *Escherichia coli* intestinal bacterium based on an entirely synthetically constructed DNA [25] and an earlier effort based on *Mycoplasma mycoides* [13]. Other efforts have mixed pre-existing with synthetically constructed DNA. All of these projects are light years away from producing conscious agents, let alone creative ones. Nonetheless, it seems safe to suppose that creative artefacts of the future will not much resemble the clunky mechanical devices that the term “artefact” often conjures up today, even as they may not bear much resemblance to naturally occurring terrestrial cell-based life, either. Likewise one can expect that their creative expressions will exhibit “*creativity, but not as we know it*” [9, p. 25].

As for what counts as “alive”, one should not – on my view, as should be clear when I called the artefactual question a red herring – be prejudiced by what “stuff” something is made of, be it carbon or silicon, cell- or processor-based or something else again. A function-based definition that abstracts away from any familiar laundry list of biological properties seems preferable. I take inspiration from Francisco Varela and Humberto Maturana’s notion of *autopoiesis* [16], which deliberately does just that: abstracting away from life-as-we-know-it to describe life in functional terms as a kind of homeostatic machine where “. . . the organization of a machine is independent of the properties of its components which can be any, and a given machine can be realized in many different manners by many different kinds of components” [16, p. 77].¹⁴ Such a machine defines its own, selectively permeable boundary between itself and the world; is organizationally closed, its structure determined and maintained by processes within itself; and is autonomous in the strong sense, as opposed to giving the partial appearance of autonomy [24, p. 5].

Are human beings – are all organisms on Earth – machines? In a functional sense, yes.

I am not aware of anyone claiming their artefact to be creative who also claims it to be conscious, nor of anyone claiming their artefact to be (“minimally” or otherwise) conscious who also claims it to be alive. Why is that? I think it’s because, for many people, creativity seems – on the face of it – like not such a hard thing to emulate, even replicate, even formalize. What, they might say, is creativity *but* the artful recombination of past or present experience (whatever exactly “experience” is taken to be)?

Consciousness, on the other hand, seems much harder to get a grasp on – perhaps because conscious agents, seeking to explain consciousness, are necessarily seeking to explain their *own* consciousness, and how does one step outside one’s own consciousness to do that? One feels some sympathy for the Churchlands [6, 5] (or, really, Daniel Dennett [10]) who would try to explain and reduce it straight out of existence. What separates life from non-life, organic from inorganic matter, seems that much bigger of a question – and really, 100% synthetic DNA organisms notwithstanding, researchers haven’t a clue where to begin – except that putting a bunch of organic

compounds in a bottle and zapping it with energy is probably not going to be sufficient. But creativity, naively perhaps, seems much easier to understand, even encode into a set of rules and random-number generators for a machine. I truly do have sympathy for artist Paul Brown writing [3]:

A key problem is that of signature: at what point can we claim that an artwork has its own distinct signature? . . . I suggested that using a symbolic language to initiate a process would distance me far enough from the output of that process for it to have the potential of developing its own intrinsic qualities including a unique signature. By the 1990s it had become obvious that this approach had failed. Complementary research in many fields had demonstrated that the signatures of life were robust and strongly relativistic.

My impression is that the bottom-up “evolutionary” processes employed by the Drawbots project he was involved with at the time did not fare any better than the top-down “symbolic” approach had earlier. Why? Because evolution on its own is no solution if one does not have the right starting point. The signature of life was and is still missing.

2.3 Further requirements

Two other things deserve saying about who qualifies as a creative agent. Both are taken from the proposed list in [24] of who qualifies as a moral agent.

1. *The creative agent must be not just a conceptual agent but a sophisticated one* (cf. [24, p. 5]). In order to recognize herself as trying to be creative or trying to express that creativity to others, she must at the least have an explicit concept of self, of other, of creativity, of the creative act itself: concepts that, presumably, not all conceptual agents have. She must possess not just first-order concepts (concepts of that which purports, at least, to be non-concepts) but higher-order concepts (concepts of concepts: most importantly, perhaps, a concept of “I-as-myself” reflecting the ability to have and reflect on her sense of mental presence, of autobiographical narrative). Higher-order concepts turn their attention from the world to themselves – again, an ability that, in all likelihood, not all conceptual agents possess.
2. In parallel fashion, *the creative agent must be not just a conscious agent but an actively self-aware one* (cf. [24, p. 6]), for creativity thrives on the capacity for reflection (“what have I done?”). Remember the earlier claim that conceptual agency and consciousness are two ways of looking at the same phenomenon (where one is inclined to attribute the one, one is generally if not highly reliably inclined to attribute the other)? Drawing on a distinction common within phenomenology – between pre-reflective and reflective consciousness (see e.g. [11]) – the creative agent must be not just consciously aware but consciously aware of being consciously aware, where a good starting test for the latter might well be the ability to pass some suitable version of the mirror test.

¹⁴ Alan Turing uses “machine” in exactly this sense in [30, p. 435] before then restricting it to “digital computers”.

3 Why then computational creativity?

When one’s world becomes too small, it is time to break down the walls of that world or push those walls outward [21, p. 77].

The reader might be forgiven for thinking by this point that I find little value in discussions of computational creativity – but that could not be further from the truth. It is true that I see little to gain and much in the way of confusion to lose by attributing creativity to existing artefacts, be they programs floating in a largely virtual world or robots interacting quite directly with ours. I remain agnostic about the possibility of future artefactual creative agents, and I would not even begin to try to guess when they might be achieved: in the next five years, in my lifetime, or not for a thousand years if ever.

However, it was not the promise of independently creative agents that first got me interested in this area, back in my undergraduate days in the early 1980s. It was the potential for human-computer collaboration (see e.g. [9, p. 23]) – though “collaboration” is a loaded term, and one I would just as soon avoid any more – using technology to extend or re-imagine human capacities. It was the promise – but already increasingly then the reality, even then – that humans and computers, working together, could achieve things that lay outside either’s reach on their own. Somewhat pretentiously, I called it the “Vegar Effect”¹⁵ in an undergraduate paper, referring to a science fiction film that had come out a few years before.

3.1 Creativity transformed

Already at that time, computers were being used to create mathematical proofs that mathematicians could not arrive at on their own. The computer proof verifying the four-color theorem was achieved in 1976. Already at that time, computers were revolutionizing astronomy, facilitating the collection and processing of data on a scale not previously conceivable. By the late 1960s, computers were being used to produce the first detailed models of what happens when a star goes supernova. By the end of the 1960s, the Internet was becoming a thing, facilitating the exchange of information between researchers and universities in moments where before one had to rely on phone calls or personal meetings at conversation or paper-based publications – remember those? Now, of course, the Internet is a thing on a whole different level – the so-called *Internet of things* – with around 1,000,000 people a day around the world gaining access for the first time. One can pull up one’s favourite search engine and have the answer to nearly any question imaginable – if an answer is to be found – in moments; and one has the tools – again, many of them computer-based – to do a pretty good job of evaluating just how reliable one can take the answer to be. All it requires is some skill in critical thinking, which the Internet certainly encourages one to practice. If it’s all a bit overwhelming sometimes, it is also breathtakingly creative.

Already at that time, visual artists like Paul Brown were using computers to explore in radically new directions that were not imaginable a few years in the past. If the human artist’s

¹⁵ The correct spelling, according to the film script, would have been “V’ger”.

“signature” remained in the digital “artist’s” output, what of it? Already at that time, computers were remaking how music got made. They inspired the creation of the first Moog synthesizer in 1964, the year I was born. Before then, synthesizers – like computers of the time – filled entire rooms. By the time I was in junior high school, mini-Moogs were cheap enough and small enough that my school could have one. The same thing, of course, was happening with computers. The first affordable desktop computers started coming out in the mid 1970s. By the early 1980s, they were becoming commonplace on university campuses, and many students had one in their rooms.

Ironically, the name “computer”, bestowed on the first digital computers in the 1940s, was a metaphor for human computers: people whose job it was to do calculations, often largely in their heads. Teams of computers would work independently to verify complex calculations. Within a few short years, those teams disappeared. What had been the metaphorical meaning of the word became the “literal” one, and what had been the “literal” meaning became the metaphor: the human mind as computer. Scores of researchers, going back to the earliest years of AI and increasing in numbers over time, took that metaphor as something approaching blasphemy. How, they said, could one compare the messy human mind, with all its creative capacity and all its capacity to get things wrong, to a computer that (many people wrongly thought, and many wrongly still think) can never get a calculation wrong, and can only do what it is told?¹⁶ As Boden writes [2, p. 29]: “Creativity and computers: what could these possibly have to do with one another? ‘Nothing’, many people would say [and have said, and continue to say, over and over again]. Creativity is a marvel of the human mind” – understood to be more powerful than any formal system.¹⁷ Attacking the metaphor of mind-as-computer became a rallying cry for all who thought there was something fundamentally *wrong* with the project of artificial intelligence. The irony behind the inverted metaphor largely got lost along the way.

3.2 Alan Turing

One person, more than any other, saw the creative potential in digital computers from the very beginning. Indeed, he had a hand in helping build one of the first ones, in Manchester, England. I am thinking, of course, of Alan Turing. Most people who are aware of his seminal paper in *Mind* [30] (which spends much of its time talking about creativity) remember it only for what they call the Turing Test and what Turing himself called the Imitation Game; and a great many of them get the “test” wrong, for Turing never said and almost certainly

¹⁶ ... A mistaken line of reasoning that can be traced back to Lady Ada Lovelace, for all the value of her other insights. For a good introduction to Lovelace’s role in the foundations of modern computing, see [14, p. 25].

¹⁷ The discussion in [26, pp. 72-77] is especially enlightening here. For a discussion of what I think is wrong with Roger Penrose’s argument – that, unlike computers, the human mind is *not* bound by Gödel’s Incompleteness Theorems – see [20, pp. 192-195]. So far as I can tell, Turing’s statement [30, p. 445] that “... although it is established that there are limitations to the powers of any particular [discrete state] machine, it has only been stated, without any sort of proof, that no such limitations apply to the human intellect” still holds.

did not believe that a computer program, successfully winning at the Imitation Game, could by virtue of having done so be said to have a human or human-like mind: in short, to think as people do. That was not the stated purpose of the game.

The most important point of that paper for me – and, I would like to think, for Turing – was what he saw as the transformative power that digital computers – still in their infancy at the time he wrote the paper – would have in getting the human mind to rethink itself, to rethink the nature of thinking itself. Turing’s greatest insight lie in seeing digital computers as a mirror by which the human mind could consider itself in ways that previously were not possible.

Turing made two predictions in the 1950 paper. One of them – that, within fifty years, “the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted” [30, p. 442] – has long ago proven its point. He was also, if I am reading him correctly, correct about the creative revolution that digital computers would unleash. What he missed – what he could not help but miss, doubtless could not imagine – was the creative revolution that his paper would unleash, within the AI community and beyond. All its insights aside, his paper is a playful work of creative fancy that has inspired two going on three generations of researchers and is being read by high school students today.

Most interpretations of the 1950 paper are controversial; people will tend to read into it what they seek to find. What is doubtless true is that Turing perceived an underlying mathematical kinship between human mind and digital computer. What is probably true is that he imagined a future in which artefacts of one kind or another – inspired, in their origins, by the digital computers he was helping to create – would take their place as fully fledged citizens in a society where the line between the artefactual and the biologically human would, for many purposes outside procreation, be blurred to the point of meaninglessness. Fanciful? Perhaps; but it does not strike me as logically outside the realms of conceivability.

What does it mean to be human?¹⁸ The power of computational creativity – the coming together of human mind and artefactual entity, a digital calculator that has become so much more – ultimately lies, I suspect, in its ability to force one to confront that question, sometimes in disquieting ways. Given the unprecedented challenges facing *homo sapiens*, the species could use all the creative energy it can get.

¹⁸ ... A question I consider at length in [21, p. 81], concluding that “... any strictly biological definition of what it means to be human will be inadequate, even in biology; but even more so in areas outside biology. Why?... because while the boundaries of ‘human being’ as a biological organism are relatively clear (although ask a biologist, and the biologist will admit that the definition of ‘species’ is not so clear cut as it might appear at first blush); the boundaries of ‘human being’ as a cognitive entity are much less so. ...”

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