The Man Who Knew Too Much: Alan Turing and the Invention of the Computer

Reviewed by S. Barry Cooper

The Man Who Knew Too Much: Alan Turing and the Invention of the Computer
David Leavitt
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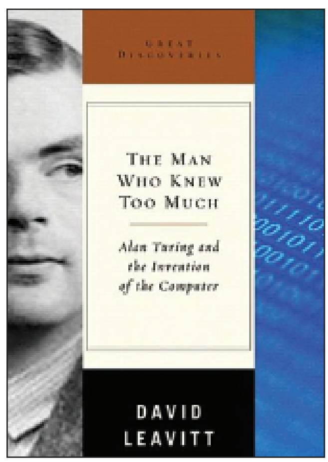
Mathematicians like to think of themselves as seekers after truth. At the same time, there is an optimistic modeling of mathematics as a rational activity based upon generally shared foundations.

Alan Turing—along with Kurt Gödel and Alonzo Church and others—was one of those metamathematical pioneers working in the 1930s who showed that the actual picture was in some ways more mundane, and in others very much stranger. And what makes Turing's work so interesting to people outside mathematics is the extent to which his mathematical investigations were tied up with his own personality and tortuous personal affairs. In many ways, Turing's mathematics was not just about what mathematicians and computers can and cannot do, but seems to many to be highly relevant to his own life and all too early death.

David Leavitt's highly readable account of Turing's life and work is yet one more example of this attention from nonmathematicians, and one that will be greeted with the usual mixed feelings by those of us who work professionally in the field. We are happy to see mathematics and mathematicians given the popular science treatment—even



when, as here, it is marred by the occasional technical gaffe. But there are many points at which David Leavitt, who (the publisher tells us) "teaches creative writing at the University of Florida," tests the reader's patience with his extra-mathematical takes on Turing's career, particularly in regard to the relationship between Turing's sexuality and his scientific work. He certainly seems to have tested that of Andrew Hodges, the perceptive and sensitive author of the definitive Turing biography (one which must be a front-runner for the best biography of a mathematician ever written). In his *Scientific American* review (January 22, 2006) of *The Man Who Knew Too Much* Hodges describes, as someone who has moved beyond 1960s posturing, how "Leavitt's focus …is on Turing as the gay outsider, driven to his death" with no "opportunity …lost to highlight this subtext"; how it is "a survey of a field long cultivated by other hands, devoid of new witnesses" (most of Leavitt's factual account of Turing is based on already published sources); but—and how could one not enjoy this readable page-turner of a book?—he concludes, the book "is one that many will find congenial and that will at least introduce new readers to the still tingling enigma of Alan Turing."

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There will, of course, be more radical and variously dissenting views on what might seem the much-hyped status of Alan Turing, in particular from those who point to the paucity of his published mathematical works, and these technically surpassed by a legion of worthy researchers for whom we will never see popular biographies. For the dissenters the continuing fascination exercised by Turing and his work is a byproduct of the mythology generated by his Bletchley Park codebreaking (shortening the Second World War by two years, it is estimated); of his controversial role as "father of the computer"; of his persecution as an openly gay man in post-war Britain; and of his mysterious premature death from the eating of an apple dipped in cyanide (which Leavitt, building on what Hodges tells us, bizarrely links to Turing's captivation by the Disney version of *Snow White and the Seven Dwarfs*).

But then, the work of Turing—and, for that matter, that of Gödel, who had great respect for Turing—is a far cry from the contemporary model involving slabs of technically proficient mathematics crafted by committees of collaborating mathematicians. No doubt, startlingly original discoveries do emerge from within quite different research paradigms, but Turing's vision was very much linked to his own peculiarly individual solitariness. If one opens the recent volume edited by Christof Teuscher, *Alan Turing: Life and Legacy of a Great Thinker* (Springer, 2004), one discovers a whole range of basic everyday issues, still scientifically relevant, to which Turing made clarifying and seminal contributions. Artificial intelligence? His most visible legacy is the Turing Test. Quantum theory related to mental functionality? Turing was there at the beginning of the discussion. The theoretical limits of machine intelligence? Turing's 1939 paper is full of key ideas, often giving rise to whole new areas of research. Some of these he never returned to (like his influential invention of the oracle model for interactive computation), while others preoccupied him until the end (such as computers that, like humans, make mistakes). And more. Measuring the complexity of computations? Turing provided a basic computational model upon which this could be based. Emergence in nature? Here we have Turing's ground-breaking 1952 paper on "The chemical basis of morphogenesis". As Hodges says in his *Scientific American* review, "Turing's reputation is now solidly underpinned by the vindication of his vision."

However, for most of us, preoccupied with the increasing pressures to conform to algorithmic performance indicators (devised by people for whom Turing's work might be salutary, but in reality has passed them by) it is Thomas Kuhn's "normal science" that dominates our professional lives. In the short term, "vision" does not cut much ice with promotion or appointments committees. Time spent clarifying deep basic questions and formulating new concepts and corresponding technical frameworks is less surely rewarded than work within well-established scientific frameworks, replete with "open problems" based on familiar parameters and established technical repertoires. The appeal of fashionable new areas, such as data mining, algorithms for genetic research, and so forth, may be viewed by the powers-that-be as much more exciting than number theory. But amongst mathematicians, it is commonly held that analysis or number theory are "deeper" than computer science or other newly emergent areas. This is a deepness that can even be marketed (like the proof of Fermat's Last Theorem, or, more lucratively, John Nash's work), but not usually for the light it throws on the world around us. More often, it is mathematics as extreme sport that catches the popular imagination. Of course, esoteric and highly abstract "normal science" does have a habit of throwing up unexpected and fundamentally important applications, but that is hard to explain to the nonspecialist.

Turing's deepness (as Hodges and Leavitt remind us) was based on an almost tactile, but at the same time quite abstract, relationship with the world he lived in. For Leavitt, Alan Turing psychologically *identifies* with the computing machines he studied in such theoretical and practical detail. This was first apparent in his 1937 paper, giving a negative solution to Hilbert's *Entscheidungsproblem*, where he bases his Turing machine model upon a detailed analysis of how a computing clerk, complete with states of mind, might perform. In Chapter 6 ("The Electronic Athlete"), I found Leavitt surprisingly convincing in arguing for Turing's identification with computing machines in a complex world, in which his own homosexuality contributed so much to his personal complexity of context. A Turing machine may compute with surprising sophistication: An *Alan* Turing machine needed to interact with the perplexities of an incongruous real world, and (as Turing himself believed) had to be enabled to make mistakes in order to be intelligent. Leavitt (p. 269) quotes Turing's letter to his friend Norman Routledge, in which he tells him of his impending Manchester court case for "gross indecency" with another male:

> I shall shortly be pleading guilty to a charge of sexual offences with a young man. The story of how it all came to be found out is a long and fascinating one, which I shall have to make into a short story one day, but have not time to tell you now. No doubt I shall emerge from it all a different man, but quite who I've not found out. …I'm rather afraid that

> the following syllogism may be used by some in the future:
>
> Turing believes machines think
>
> Turing lies with men
>
> Therefore machines do not think

Leavitt notes: "It is signed, 'Yours in distress, Alan'".

As Leavitt points out, Turing's 1937 paper is phrased in terms of the person within the machine, in apparent contrast to the present day more extensional focus on the mechanical content of the complex. But as Turing's student Robin Gandy points out in his 1988 article "The confluence of ideas in 1936", Turing's approach is a potent one. Typically, Turing starts with a more basic question than that asked by other authors. Not "What is a computable function?" But (Gandy, p. 249):

> The real question at issue is 'What are the possible processes which can be carried out in computing a [real] number?'

The result was a new model of computability very different from that previously thrown up by the logicians. The new model was instrumental in convincing the previously skeptical Gödel that the notion of in-principle computability had indeed been captured and has proved more useful than any other in the subsequent development of theoretical computer science. In following through the parallel between human complexity and that of the wider universe, the Turing model has played a key role in attempts to understand both via the mediating role of the machine.

Gödel himself, it seems, obtained his Incompleteness Theorem via an initial attempt to validate Hilbert's vision of a mathematics tamed within formal systems. One is struck by the fact that both Turing and Gödel set out to try to expand the boundaries of the mechanical within the (mathematical) world, and in so doing obtained such dramatic intimations of the nonmechanical nature of much of the universe around us. Through them, the dichotomy between the mechanical and the complex, between determinism and randomness, or between chaos and emergence, have taken more specific forms as that between the local and the global, and, more specifically, between the computable and our growing understanding of different levels of incomputability.

In his 1939 paper, based on his Ph.D. thesis written under the supervision of Alonzo Church during his stay at Princeton, Turing takes things much further. This can be seen as part of an attempt, which would occupy him for much of his remaining fifteen years of life, to extend the bounds of effectiveness beyond those he himself had established. In this marvelous paper he once again pursues his constructive agenda with unexpected outcomes. Ever alive to the real-world context of his work, this is what Turing (pages 134–5), says about the underlying meaning of his paper:

> Mathematical reasoning may be regarded …as the exercise of a combination of …*intuition* and *ingenuity*. …In pre-Gödel times it was thought by some that all the intuitive judgments of mathematics could be replaced by a finite number of …rules. The necessity for intuition would then be entirely eliminated. In our discussions, however, we have gone to the opposite extreme and eliminated not intuition but ingenuity, and this in spite of the fact that our aim has been in much the same direction.

So he is addressing the familiar mystery of how we often arrive at a mathematical result via what seems like a very unmechanical process, but then promptly retrieve from this a proof that is quite standard and communicable to other mathematicians. Another celebrated mathematician, well-known for his interest in the role of intuition in the mathematician's thinking, was Poincaré. A few years after Turing wrote the above passage, Jacques Hadamard in *The Psychology of Invention in the Mathematical Field* recounts how Poincaré got stuck on a problem (concerning elliptic functions):

> At first Poincaré attacked [a problem] vainly for a fortnight, attempting to prove there could not be any such function …[quoting Poincaré:]
>
> 'Having reached Coutances, we entered an omnibus to go some place or other. At the moment when I put my foot on the step, the idea came to me, without anything in my former thoughts seeming to have paved the way for it …I did not verify the idea …I went on with a conversation already commenced, but I felt a perfect certainty. On my return to Caen, for conscience' sake, I verified the result at my leisure.'

The experience of Poincaré may have been a dramatic one, but not one unfamiliar to the working mathematician. Who else but Turing would have attempted a mathematical explanation at that time? His argument is still not widely known (being beyond what mathematical content one can ask from Leavitt's book). Its significance is certainly not understood, except by those at ease with both the mathematics and with thinking about the world in the sort of basic terms that came naturally to Turing. What is significant is Turing's identification of incomputability with aspects of what happens in the human mind, so anticipating more recent—and more controversial—thinking on this topic. Of course, in the end Turing was faced with the jungle of incomputability in his own personal life. And when Leavitt points to the role of Turing's homosexuality in counter-posing instinct (in the form of "mechanical" basic drives) with emergent and conflicting conventional values, the relevance to his scientific life cannot be easily dismissed. Particularly interesting is Leavitt's account of Alan Turing's participation in Wittgenstein's Foundations of Mathematics course upon his return to Cambridge from Princeton towards the end of 1939. This is one of the rare occasions when we get something more than Andrew Hodges offers. Leavitt describes both Turing and Wittgenstein as "pragmatists", but with Wittgenstein taking the openly radical position that reasoning is not algorithmic and going so far as to say that paradoxes are not threatening because outside the logical formalism we have thought processes that are more powerful than the blind formal processes. But Turing's radicalism is a reluctant one, always coming from working within the machine—which may be why Turing's contribution has more fundamentally changed how we view the world. Turing is described as persistently algorithmic to the extent that he takes paradoxes arising from logic more seriously, and tries to rescue the algorithm. Both Wittgenstein and Turing are characterized as being rooted in the real world—unlike the typical professional logician or computability theorist of today—but as differing on how one balances algorithmic content and higher physical and mental processes. Here is how Leavitt sets the scene for his comments on their contrasting world-views:

> One of Wittgenstein's ambitions was to compel his students to recognize the importance of common sense even in philosophical enquiry. ('Don't treat your common sense like an umbrella,' he told them. 'When you come into a room to philosophize, don't leave it outside but bring it in with you.') Nor was it accidental that of all the participants in the seminar, it was Turing he singled out, time and again, to serve as the representative of what might be called the logicist position; Wittgenstein was, in his own words, always trying to 'tempt' Turing towards making claims that favored logic over common sense (though not always with success). As a practicing mathematician, Turing could be counted on to reiterate the traditional postulates of his discipline and in so doing give Wittgenstein the opportunity to pull the rug out from under them. Church, or someone like him, would have made a more convenient whipping boy, and had Wittgenstein known more about the unorthodoxy of some of Turing's ideas, he might have taken a different tack.

This is popular science writing of a quite high order. In *The Man Who Knew Too Much* there is certainly enough on target to make it a thoroughly recommendable book for the student or busy professional without the attention span or time to take on Andrew Hodges' more demanding 600 pages. In many ways, Turing's inner contradictions mirrored those of our own age. On the one hand, Solomon Feferman, writing in 1988 (*Turing in the Land of O(z)*, pages 131–2) confirms a generally held view:

> Turing, as is well known, had a mechanistic conception of mind, and that conviction led him to have faith in the possibility of machines exhibiting intelligent behavior.

On the other, we have Alan Turing's interest in quantum theory, found in his schoolboy writings, and re-emerging in his late postcards to Robin Gandy. In between there came his 1944-48 experiences of the ACE (Automatic Computing Engine) project, and his interest in such possibilities as machines that make mistakes. In a talk to the London Mathematical Society, February 20, 1947, he admits "… if a machine is expected to be infallible, it cannot also be intelligent. There are several theorems which say almost exactly that." And Turing also anticipated the importance now given to connectionist models of computation (as described in a 1998 article "On Alan Turing's anticipation of connectionism" by Jack Copeland and Diane Proudfoot).

A "mechanistic conception of mind" maybe, but no crude extension of the Church-Turing thesis in sight, even at a time when Turing had a huge personal investment in the development of computing machinery. Turing never ceased to emphasize the importance of computational context (quoting the LMS talk again):

> No man adds very much to the body of knowledge. Why should we expect more of a machine? Putting the same point differently, the machine must be allowed to have contact with human beings in order that it may adapt itself to their standards.

The mysteries Turing grappled with remain. To what extent is the logic of a Turing machine sufficient to capture the workings of a human brain? What is the nature of the mechanical in the physical world? And what relationship does this have to the mind?

We still try to set aside part of our professional days for the search for truth. But, partly through Turing, Gödel, and their contemporaries, we recognize that *science* is concerned with the extraction of algorithmic content and that our grasp on truth beyond that is hard won. Mathematical perceptions without proofs remain a fairly personal property, and scientific theories that, like psychoanalysis, do not make predictions do not really qualify as science. But we also know that algorithmic content often emerges in a very nonalgorithmic way, as did the proof Poincaré found as he entered the bus at Coutances.

Today, computability theoretic puzzles still lie at the core of many scientific controversies. Computability (or recursion theory as it is still sometimes termed) has come a long way since its origins in mathematical logic. Like a cuckoo in the logical nest, it made itself at home there but could never be completely constrained within logical preoccupations with language and human reasoning. This book, and the widespread interest in the life and work of Alan Turing, could help bring this fundamentally fascinating aspect of present-day science to a wider readership.