# Week 8

## Computational humanities

**Determinacy of computation meets indeterminacy of translation**

It is a truth universally acknowledged, that a single man in possession of a good fortune, must be in want of a wife.

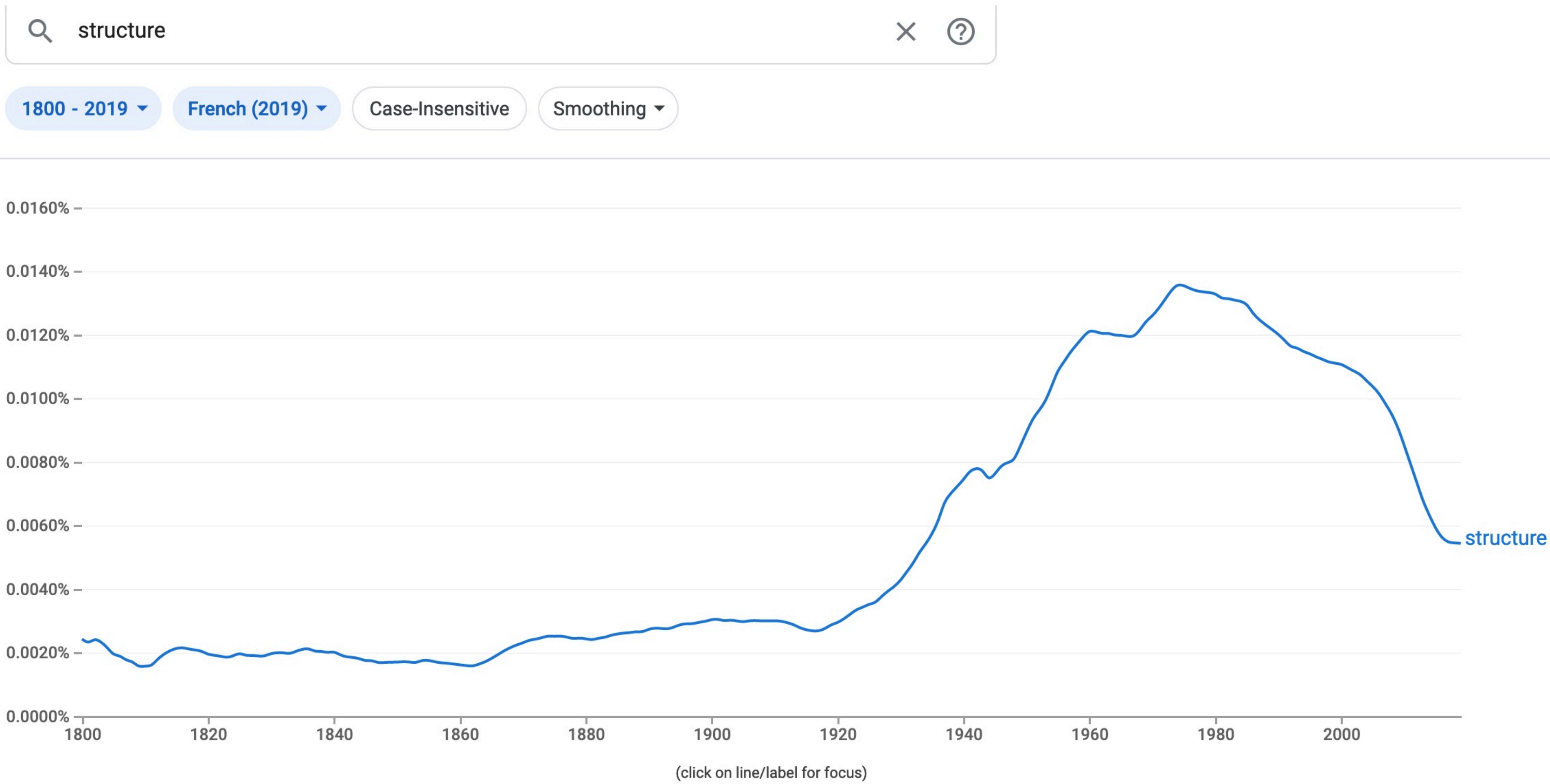
(Jane Austen, *Pride and Prejudice*)

It is a universally recognized fact that a man who is lucky should have a wife.

(Google translate, three times via Arabic.)

This is a generally accepted fact. A lucky man must lack a wife.

(Google translate, twice via Chinese)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French (2019)
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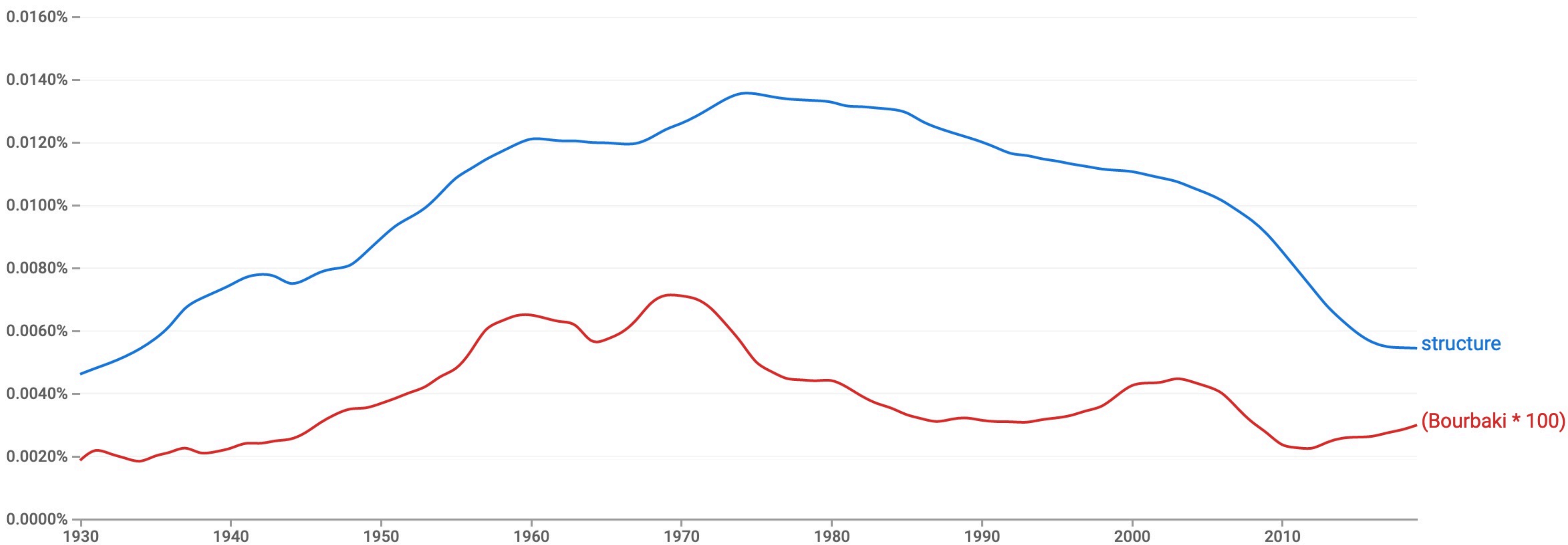

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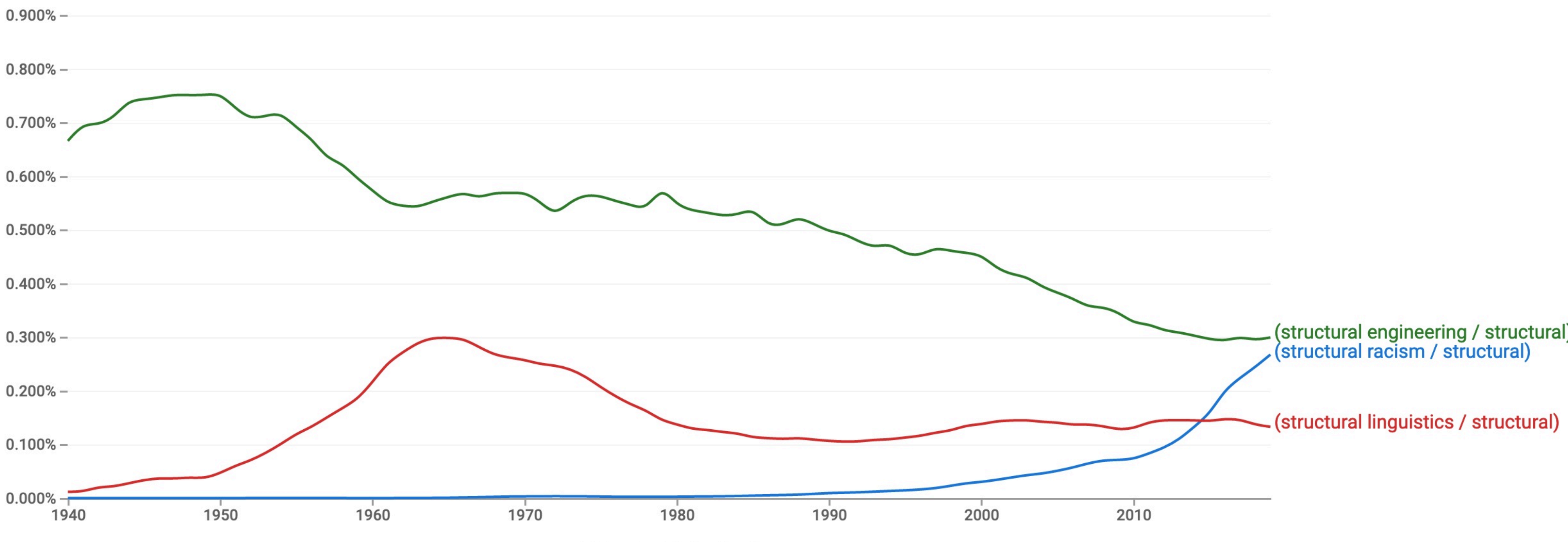

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(structural engineering / structural)
(structural racism / structural)
(structural linguistics / structural)

# Establishing a causal model

The logic of causality — *if p then q* — in a probabilistic model becomes

*if p then 30% q, 35% q', 35% q''* (etc.)

Attempts to reconcile such formal claims with experience have been unsatisfactory (70% chance of rain vs. it either rains or it doesn't; Schrödinger's cat is either dead or alive).

*A frequentist* statistical model is purely based on observation (when the current conditions have been observed, it rained 70% of the time.) The *big* in *big data* refers to the large number of observations.

The main alternative is *Bayesian*, which ascribes an intrinsic probability of a given outcome to the situation, and in particular assumes the situation is reproducible.

When 538.com's model asserts that Biden has an 88% chance of winning the election, they use complicated formulas based on observation (opinion polls) to establish a probability, without any assumption that the experiment will be repeated.

# Did Bourbaki's structures influence structuralism?

You can formulate a *null hypothesis*: there was no influence between 1950 and 1970. Then comparing the NGram graphs of *Bourbaki* and *structure* you can ask: how likely would these graphs have (roughly) similar shape under the null hypothesis? (Controlling for other possible factors, etc.)

Let X be a measure of similarity, say X = .7 for the two graphs. Here are the steps:

1. Make assumptions (usually wildly oversimplified) about the a priori distributions of shapes of graphs.
2. Assume the null hypothesis $H_0$.
3. Calculate correlations of graphs using (more or less sophisticated) probabilistic models to obtain $P(X = .7|H_0)$.
4. If $P(X = .7|H_0) < 5\%$ (at least 2 standard deviations from the mean), say we have 95% confidence that we can reject the null hypothesis.

In other words, we conclude that there was influence.

Rejecting the null hypothesis when it is true (if there was no influence) is called a **Type I error** or a **false positive**.

Accepting the null hypothesis when it is false (if there was influence) is called a **Type II error** or a **false negative**.

Exactly the same kind of reasoning goes into an individual Covid test, or testing the efficacy of hydroxychloroquine, or of a vaccine, and so on.

It is obvious that **statistical tests can never prove causality.** Much less obvious, but no less important, is the fact that the logic of statistical tests is **not** of the form "if p then q." It is much more contorted. The question the test answers is: if we assume hypothesis $H_0$, how likely are we to have observed such and such empirical results?

"If history is unpredictable, it may be because the fastest way to find out what's going to happen is to let it happen—to let the computer mundi crank out the solution in real time." (W. Paulson, Chance, Complexity, and Narrative Explanation")

*Opinion was the stable of low science while knowledge was the goal of high science. Paracelsus was the 'Luther of the physicians', as Copernicus was the Luther of the astronomers. One consequence of their twin revolution was that knowledge and opinion, formerly disparate, entered the same league. Or rather, what happenbed was that a substantial part of the potential domain of knowledge, including astronomy and the investigation of motion, became part of the domain of opinion. ... Aquinas thought one could demonstrate causes and thereby explain why things as they are. For Hume, demonstration is a matter of the 'comparison of ideas'. This operation can be performed chiefly in the realm of [deductive, MH] mathematics. Cause, on the other hand, is relegated to the other scholastic category that Hume variably calls 'opinion' or 'probability'.*

(Hacking, *The Emergence of Probability*, 1975, p. 180)

Hacking's book aims to explain how inductive reason (by correlation) came to replace deductive reason (as in pure mathematics) as the basis of science. He argues that the word *probabilitas*, from which we derive *probability*, originally meant "not evidential support but support from respected people," and quotes Aquinas: "in demonstration one is not satisfied with the probability of the proposition."

(Example of inductive reason: "all swans are white.")

There is also C. S. Pierce's *abductive reason*, or "inferring to the best explanation" of an observation. Viteri and DeDeo argue in a recent article for the role of abduction in belief formation in pure mathematics, given that no one publishes logically complete proofs.

## "Metrics" as an epiphenomenon of internet culture

*When we study the history of philosophy we want, first, to know what happened, and second, to know how what happened shaped the world we inherited. This is not a celebration, but a solemn duty. Yet this point has been entirely lost in an era in which "engagement" can only be conceptualised after the manner of online "engagement metrics", where even to mention someone is to increase their standing, to amplify their voice.… This is the inevitable outcome of a system that outsources so much of the work of assessing "standing" to machines, which, however good they may get at imitating us, in the end* ***really only know how to count****. Thus scholarly citation metrics are ultimately only another species of the genus that also includes Facebook likes or Twitter faves. In virtually every field of activity, these are the units that sustain the new economy, and they are suffocating everything about these fields that was discernibly human.… Our entire social reality is built on the model of social media.* [my emphasis]

(Justin E. H. Smith, "Notes on the Economics of Cancel Culture")

## Reading like a Terminator

What about *artificialhuman*-ities? This is the first question that comes to mind when reading Tenen's account of distributed agency. Ant colonies and beehives are not voracious readers, but artificial intelligence capable of reading and interpretation is already emerging from the interaction of programs, processors, and texts and has shown impressive compositional ability. What has yet to emerge (as far as we have been told) is an AI, like the one in *Galatea 2.0* by Richard Powers, that can express volition consistent with its way of being in the world.

# Writing like a Terminator

**Obama** : Yes. It's true. I am no longer allowed in Golden Corral.

**Interviewer** : Is this because of your extensive shrimp-n-crab legs policy?

**Obama** : Absolutely.

**Interviewer** : What is your extensive shrimp-n-crab legs policy?

**Obama** : Oh, well, in brief, they were offering an all-you-can-eat shrimp-n-crab leg buffet, and I did not hesitate. After I ate so much shrimp and crab that my stomach hurt, I would quietly sneak in and throw more shrimp and crab onto my plate. I did this over and over again until I had cleaned out the buffet and was full of shrimp-n-crab.

(GPT-3, quoted by Farhad Manjoo, *NY Times*, 7/29/20)

# **Foundations of AI *Dasein***

An android's form of life is generated by the tension among three prerequisites for its experience:

1. A program (operating instructions)
2. A data set (input)
3. A statistical model

Items 1 and 2 are characteristic of a Turing machine (no quantum computers in this fantasy). Item 3 can be viewed as part of the program but I want to treat it separately because it prescribes which features of the data are to be considered significant enough to alter the program (this can also be seen as a computable feature of the program); it can also incorporate a random feature (which is not strictly part of Turing's version).

# The AI self

One could also add

4. A goal

— for example, AlphaGo is designed to learn to win — but the aim of the thought experiment is to imagine how the AI will generate its own goal.

*we need to define the function of agency—what it does—before committing to its shape—what it is.* (Tenen, p. 15)

This is quoted out of context but it suggests that items 1-3 should suffice to determine the android's sense of self.

# Designing a story generator algorithm (SGA)

to be more complex; we expect literary characters to be more than just abstract entities serving the functional infrastructure of the plot. We also want them to be relevant: the character and her adventures must *say and mean* something to us. Moreover, we expect a character to be plausible by resembling a real person. These expectations are encapsulated in the three major criteria of character modeling that our SGA must address in combination, namely:

- narrative function,
- propositional function, and
- mimetic function.

(Jan-Christoph Meister, "Tales of Contingency, Contingency of Telling")

An AI can mimic the creation of such characters more or less well. But would an AI identify with such a character? To quote Meister again:

*are characters and subjectivity unpredictable in principle–is there just no way from calculable contingency to incalculable fate?*

# Randomness is not compatible with narrativity

A text in which the letters, or the words are chosen by a random number generator would (usually) not be recognized as a narrative, and a character whose actions are completely random would not be a recognizable character.  It is nevertheless possible to generate stories at random that follow some rules:

You may prefer to imagine an android with the features of the replicants Roy or Rachael, played by Rutger Hauer and Sean Young, in Ridley Scott's *Blade Runner*. But a theorem-proving [**or story generating**] android could equally well be the familiar cohort of monkeys with typewriters as in the "infinite monkey theorem" first proved … by the eminent French mathematician Émile Borel. The monkeys are not recruited for their intelligence but for their typing skills. The intelligence is concentrated in the typewriters: we assume they have the rules of inference built in and will not register a line unless it is a well-formed formula that follows from the preceding line. In other words, the typewriter incorporates a *proof assistant*, which is

*...typically a program which can be run on an input file (usually text), and which certifies that (1) the file adheres to a specified syntax; (2) according to specified inference rules, the document contains the proofs (and constructions) that it purports to; and (3) any errors are located.*

The medium, so to speak, of the proof is completely homogeneous. It is not punctuated by any "Aha!-Erlebnis" nor is there any possibility of communication with this android.

## Completely determined narratives are not "plausible"

The structure of Perec's *Life: a User's Manual* was determined by several arbitrary rules, or "constraints," but the narrative was nevertheless recognizably not deterministic. Compare

.0101010101010101010101010101010101010101010101010101010101010101010101

(the binary expansion of 1/3, printed by Turing's simple program) with

3.141592653589793238462643383279502884197169399375105820974944592307816

(believed, but not proved, to be completely random).

Neither makes a good story!

# Algorithmic (Kolmogorov) complexity

**Program**: print the binary expansion of 1/3.
**Program:** print 01 repeatedly.
**Program**: print the ratio between the circumference and the diameter of a circle.

The first two programs give the same result, but the first requires additional computation steps. The third is longer than the first two, especially once the concepts and all their prerequisites are encoded. Nevertheless, these are short: they do not contain much information.

Printing a random string that looks like the digits of $\pi$ but is not given by a rule contains an infinite amount of information. The notion of *algorithmic* (or *Kolmogorov*) complexity formalizes the amount of information contained in a number, or a problem: it is defined (relative to a programming language) to be the length of the shortest program in that language needed to solve that problem.

All but countably many real numbers have infinite complexity!

# Musil anticipated Kolmogorov 30 years earlier

*Human activities might be classified according to the number of words that they require; the more words there are, the worse case their character is in. All the knowledge by means of which our species has advanced from dressing in skins to flying through the air--with its proofs, all complete-would fill no more than the shelves of a small reference library, whereas a bookcase the size of the earth itself would be utterly insufficient to hold all the rest, quite apart from the very extensive discussion that has been conducted not with the pen but with chains and the sword.*

(Musil, *The Man Without Qualities* Part I, chapter 61)

*Compressibility also implies predictability, in fact gives virtually a definition of the predictable, parallel to the algorithmic definition of randomness as incompressibility: the predictable is that which is generated, by something like an algorithm, in advance of its occurrence and listing.*

(W. R. Paulson, 1994)

Can a program be designed to measure the complexity of a narrative?

Do familiar genres have optimal complexity?

Can SGAs be designed to generate stories of optimal complexity?

"What readers want from poetry is largely identified with that part of it that is incompressible" (Paulson).

That's fine for human readers, but what about artificial readers?

# Wiles's (human) proof: *fabula* or *syuzhet*?

Suppose, contrary to Fermat's claim, there is a triple of positive integers a, b, c such that

(A) $$a^p + b^p = c^p$$

for some odd *prime* number p (it's enough to consider prime exponents). In 1985, Gerhard Frey had pointed out that a, b, and c could be rearranged into

(B) a new equation, called an *elliptic curve*,

$$y^2 = x(x - a^p)(x + b^p)$$

with properties that were universally expected to be impossible.

More precisely, it had long been known how to leverage an equation like (B) into

(C) a *Galois representation*,

which is an infinite collection of equations that are related to (B), and to each other, by precise rules.

The links between (A), (B), and (C) were all well-understood in 1985. But by that year, most number theorists were convinced — mainly thanks to the insights of the *Langlands program*, named after the Canadian mathematician Robert P. Langlands — that to every object of type (C) one could assign, again by a precise rule,

(D) a *modular form*,

which is a kind of two-dimensional generalization of the familiar sine and cosine functions. The final link was provided when Ken Ribet confirmed a suggestion by Jean-Pierre Serre that the properties of the modular form (D) entailed by the form of Frey's equation (B) implied the existence of

(E) another *modular form, this one of weight 2 and level 2*.

But there are no such forms!

Therefore there is no Galois representation (C),
therefore no equation (B), therefore no solution (A).

(Logical puzzle: how can equation (B) not exist? Didn't we write it down? What would Quine say?)

This is a classic *proof by contradiction*. It works precisely because the missing link between (C) and (D) — the *modularity conjecture* — could be established.

# Wiles's proof is the beginning, not the end, of a narrative

Wiles proved the modularity conjecture — the link between (C) and (D)s, which (unlike Fermat's Last Theorem) is at the center of most of contemporary number theory. The paper with Taylor that completed the proof has been cited by 357 publications, which makes it the fifth most cited journal article in number theory of all time (the most cited article is the proof of FLT itself, with more than 600 citations!).

# The Goldbach Conjecture

**Conjecture (Christian Goldbach, 1742)**: Every even number greater than 2 is the sum of two prime numbers.

4 = 2+2, 6 = 3+3, 8 = 3+5, 10 = 3+7, 12 = 5+7, 14 = 7 + 7, 16 = 11+5,
18 = 11+7, 20 = 17+3, 22 = 17+5, 24 = 11+13, 26 = 13+13, 28 = 23+5…

Known for all even numbers less than 4000000000000000000.
(See *Uncle Petros and the Goldbach Conjecture* by A. Doxiadis).

**Ternary version**: Every odd number n greater than 5 is the sum of three prime numbers. Shown for $n > 2 \times 10^{1346}$ (starting with Vinogradov) and then for all n by Harold Helfgott in 2013.

# "Theorems for a Price"

*Although there will always be a small group of "rigorous" old-style mathematicians ...they may be viewed by future mainstream mathematicians as a fringe sect of harmless eccentrics.  ...  In the future not all mathematicians will care about absolute certainty, since there will be so many exciting new facts to discover.... This will happen after a transitory age of semi-rigorous mathematics in which identities (and perhaps other kinds of theorems) will carry price tags.*

*... I can envision an abstract of a paper, c. 2100, that reads, "We show in a certain precise sense that the Goldbach conjecture is true with probability larger than 0.99999 and that its complete truth could be determined with a budget of $10 billion."*

(Doron Zeilberger, 1993)