

The Theorem Before the Machine

PASSAGE · NON-FICTION

SKILLS TRAINED

Working memory

Delayed recall

Critical analysis

HOW TO USE THIS SHEET

About 25 minutes

- 1 Read the passage twice, slowly. Take about eight minutes.
- 2 Turn to the next page and cover this one. No looking back.
- 3 Write what you remember, then mark it on the last page.

In the autumn of 1932 a twenty-seven-year-old mathematician sat in a locked room in Warsaw with a pile of intercepted German radio traffic and no machine to compare it against. His name was Marian Rejewski. He had studied mathematics at Poznań, had been recruited with two other graduates into the Polish Cipher Bureau, and had been given a problem the bureau's older codebreakers — linguists, mostly — had failed to move. The German army was using a commercial-looking electrical device called Enigma: a typewriter keyboard, a set of rotating wheels, a lampboard, and a plugboard at the front that swapped pairs of letters before and after the wheels turned.

The number of possible settings was large enough to be quoted as a defence. What Rejewski had instead of a machine was permutation theory and a particular habit of the German operators. Each message began with a three-letter key, and the key was sent twice at the start for safety. Sending it twice linked the first letter to the fourth, the second to the fifth and the third to the sixth, in a pattern that repeated across the day's traffic. Rejewski found that the lengths of those linked chains stayed the same no matter what the plugboard did.

That was the crack. The plugboard, the most intimidating part of the device, turned out to leave a fingerprint it could not disguise, and the chains let him write equations for the wiring of the wheels themselves. A French intelligence officer had obtained German operating manuals and two months of daily keys from a source inside the cipher office, and those documents, passed to Warsaw, supplied the numbers the equations needed. By the end of December 1932 Rejewski had worked out the internal wiring of a machine he had never seen. Polish workshops began building copies.

Rejewski, Jerzy Różycki and Henryk Zygalski then spent six years industrialising the attack. They built a cyclometer to catalogue the chain patterns, a card index of all the possibilities, and perforated sheets stacked on a lightbox so that a hole showing through the pile marked a candidate setting. In 1938 they ordered six electromechanical machines called *bomby* to grind through wheel positions automatically. For most of the decade Poland read German army traffic more or less as it arrived.

Then the Germans tightened everything. Two extra wheels were added to the set in December 1938, and more plugboard connections followed, and the catalogue the three had built became useless almost overnight. Rebuilding it would have cost fifteen times the equipment they had. On 25 July 1939 the Poles met British and French officers at Pyry, in the forest south of Warsaw, and handed over everything: the methods, the sheets, the mathematics, and a working replica of the machine. The British had been working on Enigma for years and had not got in.

What happened next at Bletchley Park was not simply a continuation. The British attack abandoned the repeated key, which the Germans soon stopped sending anyway, and worked instead from cribs — guesses at phrases a message was likely to contain, such as a weather report's opening — tested by a different and much more powerful machine. That design was new. Whether the Polish work should therefore be called the foundation of the whole effort or its first chapter has been argued ever since, and the argument tends to turn on what counts as the hard part: proving the machine was breakable at all, or breaking it at the scale a war demanded.

Rejewski spent the war in France and then Britain, working on lesser ciphers, and was never told what Bletchley was doing with his replica. He returned to Poland in 1946, worked as a clerk, and wrote his account of the 1932 solution thirty years later, when the secrecy finally lifted.

- 4 The passage says the plugboard “left a fingerprint it could not disguise”. What does calling it a fingerprint tell you about what Rejewski had found?

- 5 What is the writer's attitude to Rejewski, and how is it conveyed?

- 6 Was the Polish work the foundation of the Enigma effort or its first chapter? Weigh the evidence the passage gives for each.

- 7 Evaluate the claim that Rejewski's advantage over the bureau's older codebreakers was the kind of training he had, rather than the material he was given.

PART C Mark your own work

Now go back to the passage. Tick every answer you got right. You do not need the same words as the answer below — if you wrote the same idea in your own words, it counts.

- ☐ 1 · By the end of December 1932. At Pyry they handed the British and French their methods, the perforated sheets, the mathematics and a working replica of the machine.
- ☐ 2 · Because repeating it linked the first letter to the fourth, the second to the fifth and the third to the sixth, and the same links appeared all through a day's traffic. That gave Rejewski a pattern he could measure and turn into equations, so a precaution meant to guard against radio errors became the way in.
- ☐ 3 · Because the Polish attack depended on a catalogue of chain patterns and a stack of sheets built for the old set of wheels. Enlarging the wheel set multiplied the possibilities the catalogue had to cover — rebuilding it would have taken about fifteen times their equipment — so the tools, not the mathematics, became worthless.
- ☐ 4 · A fingerprint is something an individual leaves behind without meaning to and cannot alter. The phrase means the plugboard changed which letters appeared but not the lengths of the linked chains, so its scrambling left a trace that identified the settings underneath however thoroughly it disguised the letters themselves.
- ☐ 5 · Admiring, but kept deliberately level rather than heroic. The achievement is stated flatly — he worked out the wiring of a machine he had never seen — and the admiration comes through in details like the locked room, the linguists who had failed to move the problem, and the closing facts that he was never told what Bletchley did with his replica and later worked as a clerk. The restraint lets the reader supply the verdict.
- ☐ 6 · The case for foundation is strong: the British had worked on Enigma for years without getting in, and what they received at Pyry included the proof that the machine was solvable, the wiring, a replica and the working methods. The case for first chapter is also real: the British attack dropped the repeated key the Polish method relied on, used cribs instead, and ran on a differently designed and far more powerful machine, so little of the Polish apparatus survived into the wartime work. The fair conclusion is that the Poles supplied the knowledge and the British the industry, and that the question only has a single answer if you decide in advance which of those is the hard part — which is exactly what the passage says the argument turns on.
- ☐ 7 · The passage supports it fairly well. The older staff were mostly linguists and had the same intercepts without making progress, while Rejewski came to the problem as a mathematician and attacked it with permutation theory — treating the cipher as a structure to be solved rather than a language to be read. Against that, material did matter: the French-supplied manuals and two months of daily keys gave his equations the numbers they needed, and he might not have finished without them. The honest answer is that the training determined what he could see in the traffic, and the documents determined whether he could close the calculation, so the claim is true as far as it goes but overstated as an either-or.

FACTS RECALLED IN PART A

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QUESTIONS CORRECT

— / 7

DATE

THE STRATEGY **Spaced retrieval**

Test yourself on this once today, once tomorrow, then again at the weekend — closed book each time, writing out what you can reach before you check. Spreading the attempts out feels worse than doing them in one sitting, because by the second attempt you have forgotten some of it and have to work. That difficulty is the point: a fact you retrieve after nearly losing it is held far more firmly than one you rehearse while it is still fresh.

WHERE YOU ALREADY DO THIS

What have you learned in short sessions spread over weeks rather than in one long push — an instrument, a language, a route you now drive without thinking? How well has it stayed with you compared with something you crammed?

FOR THE PARENT OR TEACHER · This sheet trains delayed recall, not reading speed. Let your teenager read the passage once, then cover it completely before Part A — no glancing back and no prompting, because the effort of hauling a half-remembered fact out of memory is what fixes it there. At this level mark the thinking rather than the wording: the answers given for the inference, tone and analysis questions are one good response each, not the only one.