|  |  |
| --- | --- |
| Cover Image | *How Not to Be Wrong : The Power of Mathematical Thinking (9780698163843)* Ellenberg, Jordan  Penguin USA |

|  |
| --- |
| This document is overwritten when you make changes in Play Books.  You should make a copy of this document before you edit it. |

# *8 notes/highlights*

*Created by Tarang Shah*  – Last synced July 10, 2016

## *WHEN AM I GOING TO USE THIS?*

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | |  | *So here’s the question. You don’t want your planes to get shot down by enemy fighters, so you armor them. But armor makes the plane heavier, and heavier planes are less maneuverable and use more fuel. Armoring the planes too much is a problem; armoring the planes too little is a problem. Somewhere in between there’s an optimum. The reason you have a team of mathematicians socked away in an apartment in New York City is to figure out where that optimum is. The military came to the SRG with some data they thought might be useful. When American planes came back from engagements over Europe, they were covered in bullet holes. But the damage wasn’t uniformly distributed across the aircraft. There were more bullet holes in the fuselage, not so many in the engines. Section of plane Bullet holes per square foot Engine 1.11 Fuselage 1.73 Fuel system 1.55 Rest of the plane 1.8 The officers saw an opportunity for efficiency; you can get the same protection with less armor if you concentrate the armor on the places with the greatest need, where the planes are getting hit the most. But exactly how much more armor belonged on those parts of the plane? That was the answer they came to Wald for. It wasn’t the answer they got. The armor, said Wald, doesn’t go where the bullet holes are. It goes where the bullet holes aren ’ t: on the engines. Wald’s insight was simply to ask: where are the missing holes? The ones that would have been all over the engine casing, if the damage had been spread equally all over the plane? Wald was pretty sure he knew. The missing bullet holes were on the missing planes. The reason planes were coming back with fewer hits to the engine is that planes that got hit in the engine weren’t coming back. Whereas the large number of planes returning to base with a thoroughly Swiss-cheesed fuselage is pretty strong evidence that hits to the fuselage can (and therefore should) be tolerated. If you go the recovery room at the hospital, you’ll see a lot more people with bullet holes in their legs than people with bullet holes in their chests. But that’s not because people don’t get shot in the chest; it’s because the people who get shot in the chest don’t recover. Here’s an old mathematician’s trick that makes the picture perfectly clear: set some variables to zero . In this case, the variable to tweak is the probability that a plane that takes a hit to the engine manages to stay in the air. Setting that probability to zero means a single shot to the engine is guaranteed to bring the plane down. What would the data look like then? You’d have planes coming back with bullet holes all over the wings, the fuselage, the nose—but none at all on the engine. The military analyst has two options for explaining this: either the German bullets just happen to hit every part of the plane but one, or the engine is a point of total vulnerability. Both stories explain the data, but the latter makes a lot more sense. The armor goes where the bullet holes aren’t.*  May 24, 2016 | [14](http://play.google.com/books/reader?printsec=frontcover&output=reader&id=f0CDCAAAAEAJ&source=books-notes-export&pg=GBS.PA14.w.0.0.0.4.0.1) | |

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | |  | *To a mathematician, the structure underlying the bullet hole problem is a phenomenon called survivorship bias . It arises again and again, in all kinds of contexts. And once you’re familiar with it, as Wald was, you’re primed to notice it wherever it’s hiding.*  May 24, 2016 | [17](http://play.google.com/books/reader?printsec=frontcover&output=reader&id=f0CDCAAAAEAJ&source=books-notes-export&pg=GBS.PA17.w.0.0.0.4) | |

## *PART I: Linearity*

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | |  | *The difference between the two pictures is the difference between linearity and nonlinearity, one of the central distinctions in mathematics. The Cato curve is a line; \* the non-Cato curve, the one with the hump in the middle, is not. A line is one kind of curve, but not the only kind, and lines enjoy all kinds of special properties that curves in general may not. The highest point on a line segment—the maximum prosperity, in this example—has to be on one end or the other. That’s just how lines are. If lowering taxes is good for prosperity, then lowering taxes even more is even better. And if Sweden wants to de-Swede, so should we. Of course, an anti-Cato think tank might posit that the line slopes in the other direction, going southwest to northeast. And if that’s what the line looks like, then no amount of social spending is too much. The optimal policy is Maximum Swede.*  May 28, 2016 | [32](http://play.google.com/books/reader?printsec=frontcover&output=reader&id=f0CDCAAAAEAJ&source=books-notes-export&pg=GBS.PA32) | |

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | |  | *Now here’s the conceptual leap. Newton said, look, let’s go all the way. Reduce your field of view until it’s infinitesimal —so small that it’s smaller than any size you can name, but not zero. You’re studying the missile’s arc, not over a very short time interval, but at a single moment. What was almost a line becomes exactly a line. And the slope of this line is what Newton called the fluxion , and what we’d now call the derivative .*  May 28, 2016 | [52](http://play.google.com/books/reader?printsec=frontcover&output=reader&id=f0CDCAAAAEAJ&source=books-notes-export&pg=GBS.PA52) | |

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | |  | *The trouble started with Zeno, a fifth-century-BCE Greek philosopher of the Eleatic school who specialized in asking innocent-seeming questions about the physical world that inevitably blossomed into huge philosophical brouhahas. His most famous paradox goes like this. I decide to walk to the ice cream store. Now certainly I can’t get to the ice cream store until I’ve gone halfway there. And once I’ve gone halfway, I can’t get to the store until I’ve gone half the distance that remains. Having done so, I still have to cover half the remaining distance. And so on, and so on. I may get closer and closer to the ice cream store—but no matter how many steps of this process I undergo, I never actually reach the ice cream store*  May 28, 2016 | [53](http://play.google.com/books/reader?printsec=frontcover&output=reader&id=f0CDCAAAAEAJ&source=books-notes-export&pg=GBS.PA53.w.0.0.0.1) | |

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | |  | *It’s hard to defend Cauchy’s stance on pedagogical grounds. But I’m sympathetic with him anyway. One of the great joys of mathematics is the incontrovertible feeling that you’ve understood something the right way, all the way down to the bottom; it’s a feeling I haven’t experienced in any other sphere of mental life. And when you know how to do something the right way, it’s hard—for some stubborn people, impossible—to make yourself explain it the wrong way.*  May 29, 2016 | [60](http://play.google.com/books/reader?printsec=frontcover&output=reader&id=f0CDCAAAAEAJ&source=books-notes-export&pg=GBS.PA60.w.0.0.0.4) | |

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | |  | *Linear regression is a marvelous tool, versatile, scalable, and as easy to execute as clicking a button on your spreadsheet. You can use it for data sets involving two variables, like the ones I’ve drawn here, but it works just as well for three variables, or a thousand. Whenever you want to understand which variables drive which other variables, and in which direction, it’s the first thing you reach for. And it works on any data set at all.*  May 29, 2016 | [65](http://play.google.com/books/reader?printsec=frontcover&output=reader&id=f0CDCAAAAEAJ&source=books-notes-export&pg=GBS.PA65) | |

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | |  | *That’s a weakness as well as a strength. You can do linear regression without thinking about whether the phenomenon you’re modeling is actually close to linear. But you shouldn’t. I said linear regression was like a screwdriver, and that’s true; but in another sense, it’s more like a table saw. If you use it without paying careful attention to what you’re doing, the results can be gruesome*  May 29, 2016 | [65](http://play.google.com/books/reader?printsec=frontcover&output=reader&id=f0CDCAAAAEAJ&source=books-notes-export&pg=GBS.PA65.w.0.0.0.1) | |