What Is a Healthy Skeptic

Healthy skeptics are good Bayesians. This paper explains what that means.

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Good Bayesians hold a belief, never with certainty, and let evidence update it by its strength. Two people can read the same study and reach opposite conclusions without either misreading it. Each weighs the evidence against what she already believes. That is Bayesian reasoning, and people do it whether or not they have heard of Bayes. Doing it well is the whole of healthy skepticism.

How evidence moves a belief

Before you see any evidence, you already have some confidence in the claim. That is the prior, a number between zero and one. Zero means the claim is impossible. One means it is certain.

Evidence for the claim raises the prior. Evidence against it lowers it. Bayes's rule says by how much: it multiplies the prior by the strength of the evidence. Strength has a simple test. How much more often would you see this evidence if the claim were true than if it were false? The result is the posterior, your confidence after the evidence. Updating a prior into a posterior is all a Bayesian does, and the posterior becomes the prior for the next piece of evidence.

There is rigorous mathematics behind all of this. You do not need any of it to be a good Bayesian. What you need is the habit: know your prior, and let the evidence move it by its strength.

Suppose a supplement is said to prevent colds. A neighbor swears by it. You would hear that story whether or not the supplement works, so it is weak evidence and your confidence barely moves. A trial of a few thousand people in which those on the supplement had fewer colds is something you would rarely see if the supplement did nothing. That is strong evidence, and your confidence should rise. How far it rises depends on where it started.

Now give the trial to two readers. One has followed supplement claims for years and starts with little confidence that any of them work. The other has no view. The trial is the same for both, so the same evidence acts on each reader's prior. Both end up more confident than they started. The doubter now thinks the supplement might work. The other reader is fairly sure it does. They read the same trial, both reason well, and they still disagree. It would take more trials to bring the doubter to where the second reader already is. The one reader Bayes's rule cannot move is the one whose confidence began at zero. Bayes's rule always works. What fails is the prior.

Bayes T. An essay towards solving a problem in the doctrine of chances. Philosophical Transactions of the Royal Society 1763;53:370-418.

Why a prior should never be zero or one

Bayes's essay was read to the Royal Society in 1763, two years after his death. Before the first observation, he assigned some weight to every possible value of the unknown chance. Nothing was ruled out. Doubt is built into the essay.

Dennis Lindley named it Cromwell's rule, after Cromwell's 1650 letter to the Church of Scotland: "I beseech you, in the bowels of Christ, think it possible that you may be mistaken." Lindley's version: leave a little probability for the moon being made of green cheese, as small as one in a million, or an army of astronauts returning with samples will leave you unmoved.

Certainty leaves no opportunity to be swayed by the evidence. It is a refusal to reason. A strong belief sits near zero or near one, depending on how the claim is stated, and can still be moved by enough evidence. A healthy skeptic can hold a strong belief. What she cannot do is hold a certain one. That is the first rule of a good Bayesian.

Lindley DV. Making Decisions, 2nd ed. Wiley, 1985, p. 104. Cromwell O. Letter to the General Assembly of the Church of Scotland, 3 August 1650.

The closed mind and the credulous mind

The closed mind. A person who holds that vaccines cannot do good has set that prior at zero. A randomized trial of 1,759 parents shows what that does. Parents were shown the CDC's correction of the claim that MMR causes autism. The correction moved the belief it aimed at: fewer parents believed the claim afterward. It did not move the belief that governs the decision. Among parents with the least favorable views of vaccines, intent to vaccinate fell from about 70 in 100 to about 45 in 100. A prior at zero stays at zero. Why it moved the wrong way is a different question. The jury section takes it up.

Nyhan B, Reifler J, Richey S, Freed GL. Effective messages in vaccine promotion: a randomized trial. Pediatrics 2014;133:e835-e842.

The credulous mind. The opposite failure is a prior that sits wherever the last claim left it. In 1998 the Lancet published a paper on twelve children with no comparison group. It suggested a link between MMR and autism. MMR coverage in England was 92 in 100 two-year-olds in 1996. By 2004 it was 80 in 100. The paper was retracted in 2010. A pooled analysis of more than 1.2 million children found no association. Twelve children with nothing to compare against carry almost no weight. The prior should barely have moved.

Wakefield AJ et al. Lancet 1998;351:637-641, retracted Lancet 2010;375:445. Coverage: Millward G. Vaccinating Britain. Manchester University Press, 2019, chapter on MMR. Taylor LE, Swerdfeger AL, Eslick GD. Vaccine 2014;32:3623-3629.

In both cases the evidence stopped mattering. The closed mind will not move. The credulous mind moves all the way on anything, which is the same as having no belief of its own. Neither is a Bayesian. A healthy skeptic is neither a cynic, who has decided in advance, nor a pushover, who decides nothing. She holds a prior, knows what it is, and lets the evidence move it by its strength.

A drug advertisement

A magazine ad for Lipitor said the drug cuts the risk of heart attack by 36%. The trial behind it followed about 10,000 people with high blood pressure for three years. Of every 1,000 on placebo, 30 had a heart attack. Of every 1,000 on the drug, 19 did. Eleven people in 1,000 were spared. Eleven is 36% of 30.

The credulous reader hears 36 and takes it as 36 in 100 helped. The closed reader has decided drug companies lie and dismisses the trial with the ad. The healthy skeptic's prior is that a headline reduction is a relative number. She asks for the baseline and lands on 11 in 1,000. That number is real. Her prior

was not about the drug. It was about how drug claims are written. That prior comes from experience with past claims.

Sever PS et al. ASCOT-LLA. Lancet 2003;361:1149-1158. Counts per 1,000 rounded from the trial's 1.9% and 3.0%.

A tax audit

A tax examiner opens a file already expecting to find an adjustment. A tax attorney writing for practitioners described the standard an examiner is meant to hold as fair skepticism. The phrase is not in the manual, but the manual says both halves in its own words. The two words are the two halves of a prior. Fair skepticism is healthy skepticism applied to a tax return.

The skepticism stems from the record. The IRS selects many returns for audit using a scoring formula based on past audits. Of returns audited with incomes between $25,000 and $200,000, about 88 in 100 result in a change to the tax owed. A return selected by that formula deserves a higher prior than one chosen at random. The manual says the same: oral testimony need not be accepted without further inquiry. That is how a prior should be set.

Fair is the other half, and it fails at two points. The first occurs when the prior shifts from the return to a belief about the person. The formula scores the return. It says nothing about intent. An error and a lie produce the same adjustment, and nothing in the score distinguishes them. An examiner who reads the score as "this taxpayer is hiding something" has turned a prior about a return into a judgment of a person. Nothing in the file supports that. Ordinary prejudice fails the same way. It is a prior about who the taxpayer is, not about what the return shows. It comes from the wrong record.

The second occurs when the prior is set to one. In fiscal 2021, about 12 in 100 of those middle-income audits closed with no change. Above $5 million, it was about 38 in 100. Those returns were selected the same way. The prior was high, and still, one file in ten, or one in three, had nothing in it. An examiner at a prior of one cannot see a clean file. Every receipt looks like part of a cover-up. The manual asks for a balanced and impartial evaluation of all the evidence. That examiner is skeptical but not fair.

GAO. Tax Compliance: Trends of IRS Audit Rates and Results for Individual Taxpayers by Income. GAO-22-104960, May 2022, figure 4. Selection: GAO. Tax Administration: IRS' Return Selection Process. GAO/GGD-99-30, 1999. Internal Revenue Manual 4.10.7.3.2 (oral testimony) and 4.10.7.4 (balanced and impartial evaluation).

A jury

The law gives each juror a prior, the presumption of innocence, and a threshold, proof beyond reasonable doubt. What it cannot do is make twelve people start with the same prior or give the same weight to the same testimony.

Kalven and Zeisel found that about 5 in 100 American juries hung, or one in twenty. The National Center for State Courts later found 6 in 100 in large urban state courts and about 2 in 100 in federal courts. In both studies, hung juries came mostly from juries split or nearly split on the first ballot. When the first vote was lopsided, the majority's verdict almost always stood. Everyone in the room heard the same evidence. A split on the first ballot reflects differences in priors and in the weight each juror gave the testimony.

Deliberation can share evidence. A juror who missed a detail can be told about it. Deliberation cannot share a prior. A juror at zero or one cannot be deliberated with. Nothing said in the room can move such a prior. That juror is the holdout. A healthy skeptic can be a holdout too, but only while the evidence is still short of the threshold, and she can say what would get it there.

Kalven H, Zeisel H. The American Jury. Little, Brown, 1966. Hannaford-Agor PL, Hans VP, Mott NL, Munsterman GT. Are Hung Juries a Problem? National Center for State Courts, 2002.

One more finding goes beyond Bayes. In 1979, Lord, Ross, and Lepper gave 48 students, supporters and opponents of the death penalty, the same two studies, one finding that it deters murder and the other that it does not. Each side judged the study that agreed with it the better one. After reading both, each side held its position more strongly. In Bayes's rule, the prior sets where you start, and the evidence sets how far you move. People also let the prior change how they weigh the evidence. That is what happened to the parents whose intent fell after the correction and to the juror who hears the same witness as everyone else and believes the opposite. A healthy skeptic knows this happens and watches for it in herself.

Lord CG, Ross L, Lepper MR. Biased assimilation and attitude polarization. Journal of Personality and Social Psychology 1979;37:2098-2109.

Summary

Every judgment is made against a prior. Everyone has one. Claiming to have none only hides it. So the rule is not to have no prior. It is to know yours and keep it off the ends. That is what a good Bayesian does, and a healthy skeptic is a good Bayesian.

The rule has two halves. Do not be so certain that no evidence can reach you. That is where the parents in the vaccine trial stood. Do not be so credulous that the next report of a medical breakthrough moves you all the way. That is where the parents in England stood in 1998. For each piece of evidence, ask how much more likely it is if the claim is true than if it is false, and let it move you that much.

This site and the newsletter are written for that audience. If it describes how you want to read, you are a healthy skeptic, which is to say a good Bayesian. Cromwell said it in one line. Think it possible that you may be mistaken.