HOW TO THINK

Another in a series on getting the most out of your brain.

You Can Never Prove a Theory True

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Science makes progress not by proving that theories are true but by testing them rigorously and being unable to prove them false. That's a crucial distinction to keep in mind when evaluating the claims and counterclaims that are hurled about so often on almost any issue.

An honest scientist will almost always say something is 'probably' true. A pretender will usually present statements as if there could be no doubt in the world.

There are very few things in science that can be stated honestly with absolute certainty. The closest that researchers usually get is to express a high degree of confidence that something is true. But they can reach that level of confidence only after rigorously testing the hypothesis.

For example, there is no strictly logical way to prove unquivocally that the sun will come up tomorrow. But it is possible to test that theory. You do it by looking for the sun on repeated morn-

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ings. After enough testing, you gain confidence that the theory is true. But you can't be certain it will happen the next time.

Let's study this issue with a trickier example: What are the chances that any given birth will produce a boy or a girl?

You might simply observe your own family. You might record that it has two boys and one girl. That might lead you to propose a hypothesis that nature is built so that twice as many boys are born as girls. That's fine. It's a perfectly valid hypothesis, based on real world observations.

Should you believe it? Not yet. If you want to reduce your chance of being fooled, you should first follow the standard scientific approach and test your hypothesis.

How? One simple rule is to make many observations and examine them as a group.

So you look at another family and find that it has three girls. A third family has one boy and one girl. Gradually, as you widen your sample, you find the boy-girl ratio approaches 50-50. Then, a strange thing starts to happen—once your sample approaches a certain number of families, the ratio never again varies much. You may feel satisfied that you have looked far enough.

Now you have produced a piece of scientific information—the chances of any birth producing a boy, you might conclude, are about 50 percent, and the same goes for girls. For now, let's say you are satisfied with your data.

You are now entitled to take the next step and ask why the sexes should be evenly matched.

The usual practice in science when faced with a "why" question is to think up a "because" answer. You can search your memory for something that you already know. Or you can make up something. It's okay; scientists make up explanations all the time. That's what a hypothesis is. Scientists just try not to believe them without testing them. "The sexes are equally matched," you might hypothesize, "because everybody needs somebody to love and a 50-50 ratio would make this possible."

One of the rules of the scientific method is that the only good hypothesis is one that can be tested. The "somebody to love" hypothesis is not very testable. It's the kind of hypothesis that was popular among the ancient Greeks. Objects fell downward, Aristotle taught, because the ground was their rightful place.

Since ancient times, science has developed a very different approach—testing and careful observation. In the 1930s, the late philosopher Karl Popper recognized this tradition in science, analyzed its logic and named it "critical rationalism."

"The work of the scientist," Popper wrote in a 1934 essay, "consists in putting forward and testing theories."

It was Popper who formalized the idea that theories can only be proven wrong, never right.

A hypothesis for our birth-ratio research project might be as follows. "The sexes are equally matched because parents can bequeath only two combinations of sex-determining chromosomes, and the odds that an embryo gets one or the other must be 50-50." This could be tested by looking at other species with the same chromosome situation to see whether they produce half males and half females.

Now imagine that it is a year or so later and that we have had a wonderful time on our field trips checking up on the sex ratios of lions and hummingbirds and termites and tuna. And we have looked up the reports of other scientists who have studied sex ratios for other species. We would find that not all of the ratios are 50-50. Some are but others are not. Our hypothesis needs work. It isn't as simple as we thought. We can't count on the Nobel Prize this year.

In the meantime, one of our graduate students has been examining the human birth ratio more closely and has made a surprising finding. If you look at the number of males and females at each age of life, the ratios change over time. Among newborns, boys predominate. As we move through older age groups, the ratio edges closer to 50-50. Among older people, there are more women than men. And among the elderly, there are many more women than men.

Our grad student—clearly a promising candidate—has also gotten death rates. They fit the pattern. At every age, males are more likely to die than females. He has even dug up reports showing that although more male embryos are conceived than female embryos, they are more likely to die. Females are clearly the stronger sex.

A deeper analysis of the data has revealed a phenomenon far more profound than it seemed at the outset. We can now refine our hypothesis: "Nature has arranged things so that the number of males who die before the age of parenthood is offset by the larger number of males conceived and born in the first place."

So, the "somebody to love" hypothesis w not so far off. And rigorous testing of c hypotheses has led us to a far more complex problem. The arithmetic of sex-determing chromosomes would seem to dictate a 50-50 ratio. The fact that nature doesn't work that way shows that a more subtle phenomenon must be at work.

We need another grant.