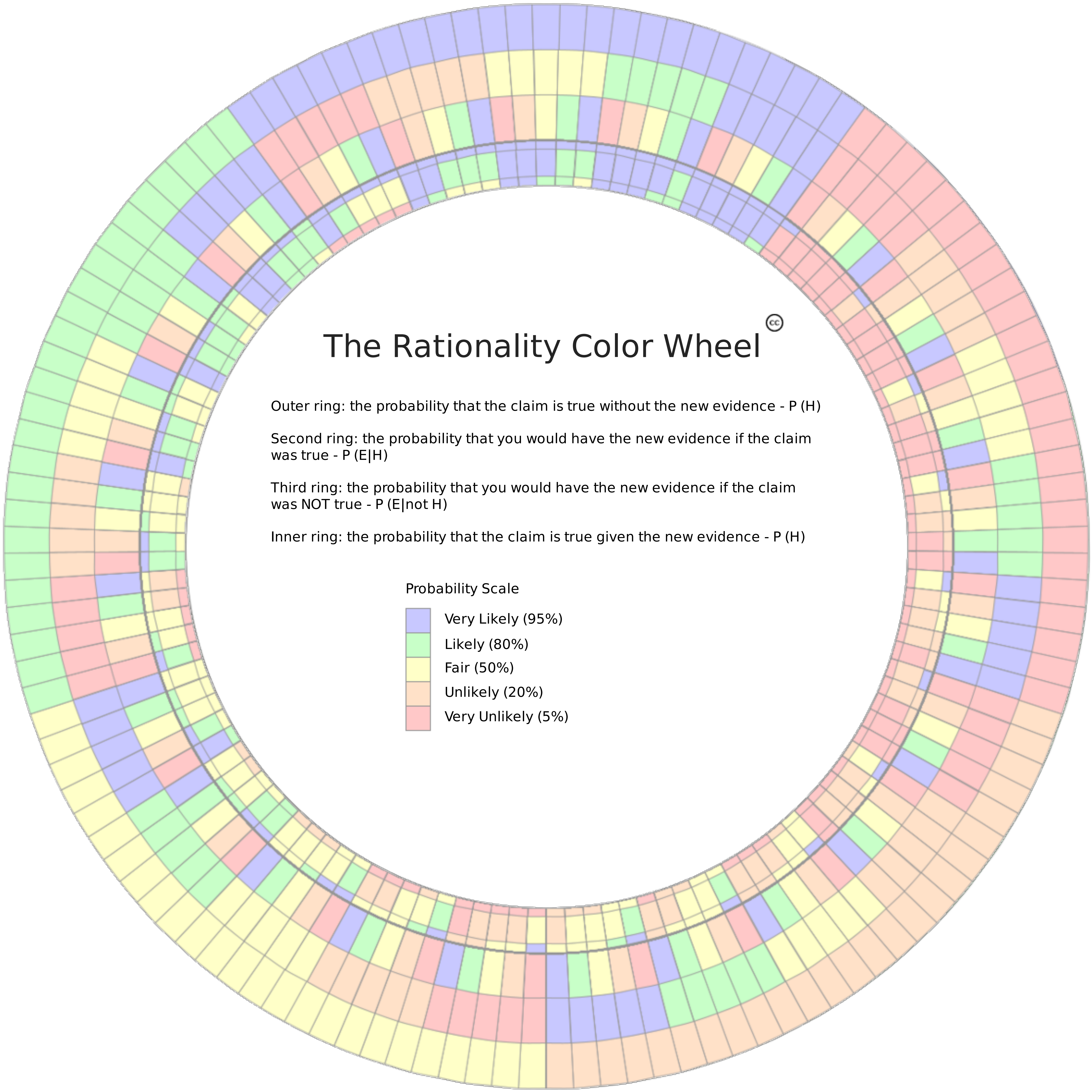
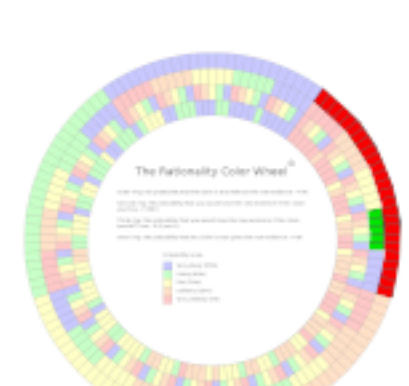


The Rationality Color Wheel is a tool for weighing evidence. When presented with evidence for a claim, simply move your finger from one color region to the next to determine how likely the claim is given the evidence. For example:

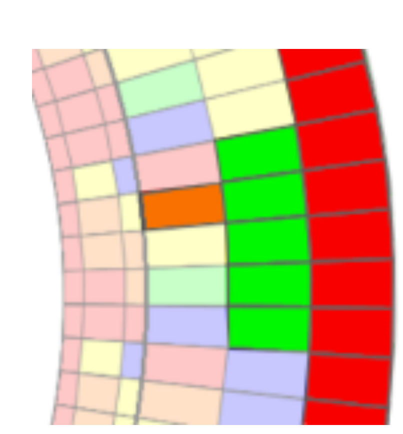
Imagine that a woman takes a medical test to determine whether or not she has a rare disease that afflicts 2% of the population. The test is highly sensitive: when a person has the disease, it returns a positive result 90% of the time. When they don't, it returns a positive result 10% of the time. The woman gets a positive test result. What is the likelihood that she has the disease?

Only 2% of the population has the disease, so before the test result, the woman was "very unlikely" to have the disease. Therefore, start in the red segment of the outermost ring.

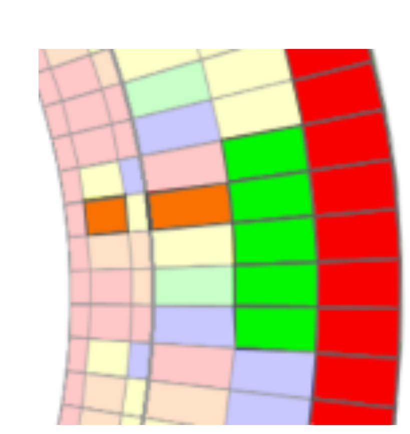
When a person has the disease, they are "likely" (90%) to get a positive test result. Therefore, move to the green region in the second ring.



When a person does not have the disease, they are "unlikely" (10%) to have a positive test result. So we move inward to the orange region in the third ring.



Now, we simply move inward to the **middle** color in the adjacent cell. It's orange so we conclude that the woman is "unlikely" to have the disease.



When given this scenario, many people incorrectly believe that the woman has a high probability of having the disease. However, we can easily find the correct answer by using the color wheel.

The probability that a claim is true is represented by a segment with three colors. The outer color gives the maximum possible probability that the claim is true. The central color gives the probability that the claim is true when the colors values equal those in the legend. The inner color gives the smallest possible probability that the claim is true. These bounds are necessary because each color represents a range of possible values. The calculations are based on Bayesian Inference, a branch of mathematics used for statisticians in science, medicine, and research. Learn more about Bayesian Inference at https://en.wikipedia.org/wiki/Bayesian_inference.

Larry D. Lee Jr. 2023 v3.2.0

Rationality Color Wheel Worksheet Introduction

This worksheet is part of a series that illustrates how you can use the Rationality Color Wheel to think critically.

Cause and Effect

Let's say that someone claims that doing A increases the likelihood of some outcome O. We can weigh their argument using the color wheel.

Step 1: how often did the outcome occur in general? Place your finger on the corresponding color in the outer ring.

Step 2: how often did the action precede the outcome? Move your finger inward to the corresponding color in the second ring.

Step 3: how often did the action precede the alternative outcome? Move your finger inward to the corresponding color in the third ring.

Step 4: move your finger inward to the adjacent cell? Its color indicates the probability that a person who did the action experienced the outcome.

The following worksheets illustrate how to use the color wheel to assess claims of cause and effect and to weigh evidence generally.

Rationality Color Wheel Worksheet 1

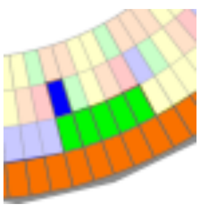
This worksheet is part of a series that illustrates how you can use the Rationality Color Wheel to think critically.

Cause and Effect

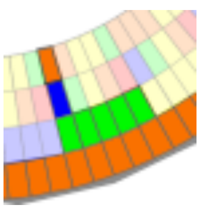
Example 1: Researchers studied 1,000 people who developed a dangerous disorder that has a 20% survival rate. They found that 80% of those who survived took an homeopathic remedy. Of those who died, 40 did not take the homeopathic remedy. Did the remedy help?

A randomly selected person was "unlikely" (20%) to survive the disease.

An ill person who survived was "likely" (80%) to take a homeopathic remedy.



But those who did not survive were "very likely" (95%) to have taken a homeopathic remedy (only 40 (5%) out of the 800 people who died did not take a remedy).



Hence, we can see that those who took the homeopathic remedy were "unlikely" to survive. The homeopathic remedy did not help (it actually reduced the likelihood of survival).

Can you think of instances where you have seen stories advocating for alternative medicines presented like this one? Did you find the result surprising? Did you find it misleading? How do you think advertisers and online "influencers" might use similar "facts" to attract attention and make money?

Rationality Color Wheel Worksheet 2

This worksheet is part of a series that illustrates how you can use the Rationality Color Wheel to think critically.

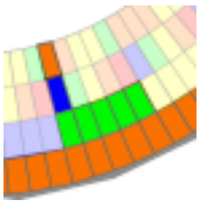
Cause and Effect

Example 2: Researchers surveyed 1,000 entrepreneurs and found that 20% of them were successful. Of those who were successful, 80% "avoided overthinking" and "trusted their intuition" when making important business decisions. They interviewed the 40 unsuccessful entrepreneurs who relied on critical thinking and concluded that intuitive decision making was superior. Should you follow their advice?

A randomly selected entrepreneur was "unlikely" (20%) to be successful.

A successful entrepreneur was "likely" (80%) to "avoid overthinking".

But those who failed were "very likely" (95%) to rely on intuition (only 40 (5%) of the 800 people who failed used critical thinking).



Hence, we can see that those who relied on intuition were actually "unlikely" to succeed (critical thinking actually increased the likelihood of success in business).

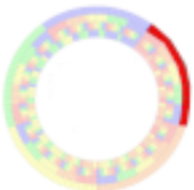
Can you think of times when you've heard similar advice? When people advise you to "trust your gut," and to "trust your instinct" how often do they present stories like this one? This story hid the behavior and outcomes of those who failed to mislead you. Can you recall justifications you've heard that omitted this kind of information completely?

Rationality Color Wheel Worksheet 3

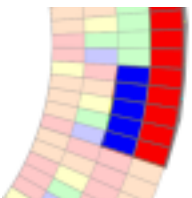
This worksheet is part of a series that illustrates how you can use the Rationality Color Wheel to think critically.

Evidence and Tests

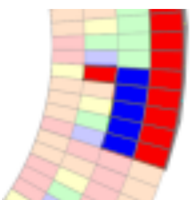
Example 3: A resident of a small town commited a crime. A detective in the town narrows down the potential suspects to 20 people and decides to use a forensic test to pin down the culprit. The test is sensitive. If a person commited the crime, the test will return a positive result 95% of the time, and has a false positive rate of only 5%. The test returns a positive result for one of the suspects. Has the detective found her perp?



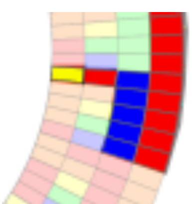
Before the test, each suspect is "very unlikely" (5%) to be the culprit.



If a suspect is guilty, they are "very likely" (95%) to get a positive test result.



If a suspect is innocent, they are "very unlikely" (5%) to get a positive test result.



Yet, the color wheel correctly shows, that the suspect flagged by the test only has a "fair" (50%) chance of being the culprit (literally a coin toss)!

Was this result surprising? What did you think the likelihood was? Our intuition about probability is often wrong. How might errors like these play out in a jury? How might errors like these play out in other areas of society?

Rationality Color Wheel Advanced Notes

In this note, we explain how the Rationality Color Wheel was created, discuss the math behind it, and provide guidance for advanced use.

Bayes' Formula

The Rationality Color Wheel is based on Bayes' formula. Given a hypothesis H and some new evidence E, we can compute the probability that H is true using the facts that were available before E. We express this probability as $P(H)$. We then compute the probability that we would have E given that H is true. We write this probability as $P(E|H)$. Likewise, we compute the probability that we have E given that H is **not** true, which we write as $P(E|\neg H)$. Bayes formula tells us how to combine these probabilities to compute the probability that H is true *given* E, which we write as $P(H|E)$. Bayes' formula can be written as:

$$P(H|E) = \frac{P(E|H)P(H)}{P(E|H)P(H) + P(E|\neg H)(1 - P(H))} \tag{1}$$

Construction

The Color Wheel makes it easy to compute this formula. It divides the range of possible probabilities into five intervals: "very unlikely," "unlikely," "fair," "likely," and "very likely." And assigns a color to each range.

Color	Minimum Value	Maximum Value	Interpretation	"Standard" Value
Red	0%	5%	"Very unlikely"	5%
Orange	> 5%	20%	"Unlikely"	20%
Yellow	> 20%	< 80%	"Fair"	50%
Green	80%	< 95%	"Likely"	80%
Blue	95%	100%	"Very likely"	95%

Bayes' formula takes three input values: $P(H)$, $P(E|H)$, and $P(E|\neg H)$, and returns a single output: the "posterior" value $P(H|E)$. The Color Wheel plots out every possible combination of these values in the form of a radial disk [1]. Each slice of the disk presents one such combination and each slice has four segments. The Outermost segment represents $P(H)$. The second segment represents $P(E|H)$. The third segment represents $P(E|\neg H)$. And, the inner segment represents $P(H|E)$.

Now each color represents a range of probabilities. As a result, each combination of inputs corresponds to a range of posterior probabilities. For example, the inputs "Blue, Green, Green", could represent 100%, 80%, 90%. It could also represent 95%, 94%, and 80%. Each of these combinations have different output values - different "posteriors." To account for this, the innermost segment has three slices. The outermost represents the greatest posterior probability that could result from inputs having the given colors. The innermost represents the smallest posterior probability. The middle slice represents the posterior probability that would result if each color corresponded exactly to the "standard" values.

Nuances

The Color Wheel is intended to be used when working with probabilities that are not extremely small or extremely large [2]. It's goal is to provide a useful tool for weighing evidence concerning issues that arise in everyday life. The Color Wheel helps people get close to right answer when dealing with probabilities falling roughly between 2% and 97%.

When the input probabilities are close to the standard values, the middle slice of the innermost segment should give a good estimate of the true posterior probability. When dealing with extremely small and extremely large probabilities however, the upper and lower bounds on the Color Wheel become increasingly relevant. For example, the inputs "Red, Red, Red" can imply that the posterior probability is either very high or very low. This is indicated by the upper and lower bounds for this slice.

As a general rule, **increasing the probability of the outermost and second rings moves the posterior probability closer to the upper bound. Increasing the probability of the third ring moves the result closer to the lower bound.**

So, for example, let $P(H) = 79\%$ (high yellow), and the remaining values equal the standard value for Green: $P(E|H) = 80\%$ and $P(E|\neg H) = 80\%$. Then the true result will be closer to the upper bound (Green) indicated in the Color Wheel. Conversely, let $P(H) = 21\%$ (low yellow) and the actual result will be closer to the lower bound (Orange) indicated in the Color Wheel. In both cases, because only one input moved, we know that the true value is between the "middle" value and the mentioned bound.

Conclusion

Bayesian inference is a very powerful method. We hope that the Color Wheel has both empowered you and sparked your curiosity. Have fun and tell others about the Rationality Color Wheel!

Footnotes

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1. Originally, we intended to create a paper handtool in which users rotated the wheel behind a screen that had a single slit in it that revealed only one slice of the table. This was the original motivation for the radial design. ↩

2. By "extremely small," we mean values much less than 1%. By "extremely large," we mean probabilities much greater than 99%. ↩