

10.1: What Do Probabilities Mean?

It might strike you that it is a bit odd to talk about the probability of a person having cancer depending on a test result; after all, the person either has cancer or they don't. Historically, there have been two different ways that probabilities have been interpreted. The first (known as the *frequentist* interpretation) interprets probabilities in terms of long-run frequencies. For example, in the case of a coin flip, it would reflect the relative frequencies of heads in the long run after a large number of flips. While this interpretation might make sense for events that can be repeated many times like a coin flip, it makes less sense for events that will only happen once, like an individual person's life or a particular presidential election; and as the economist John Maynard Keynes famously said, "In the long run, we are all dead."

The other interpretation of probabilities (known as the *Bayesian* interpretation) is as a degree of belief in a particular proposition. If I were to ask you "How likely is it that the US will return to the moon by 2026", you can provide an answer to this question based on your knowledge and beliefs, even though there are no relevant frequencies to compute a frequentist probability. One way that we often frame subjective probabilities is in terms of one's willingness to accept a particular gamble. For example, if you think that the probability of the US landing on the moon by 2026 is 0.1 (i.e. odds of 9 to 1), then that means that you should be willing to accept a gamble that would pay off with anything more than 9 to 1 odds if the event occurs.

As we will see, these two different definitions of probability are very relevant to the two different ways that statisticians think about testing statistical hypotheses, which we will encounter in later chapters.

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