

1.1: What is Probability?

What is the scientific definition of probability? Consider an observation made on a general system, S . This can result in any one of a number of different possible outcomes. Suppose that we wish to find the probability of some general outcome, X . In order to ascribe a probability, we have to consider the system as a member of a large set, Σ , of similar, and similarly prepared, systems. Mathematicians call such a group an *ensemble* (which is just the French for “group”). So, consider an ensemble, Σ , of similar systems, S . The probability of the outcome X is defined as the ratio of the number of systems in the ensemble that exhibit this outcome to the total number of systems, in the limit that the latter number tends to infinity. We can write this symbolically as

$$P(X) = \lim_{\Omega(\Sigma) \rightarrow \infty} \frac{\Omega(X)}{\Omega(\Sigma)}, \quad (1.1.1)$$

where $\Omega(\Sigma)$ is the total number of systems in the ensemble, and $\Omega(X)$ the number of systems exhibiting the outcome X . We can see that the probability $P(X)$ must be a real number lying between 0 and 1. The probability is zero if no systems exhibit the outcome X , even when the number of systems goes to infinity. This is just another way of saying that there is no chance of the outcome X . The probability is unity if all systems exhibit the outcome X in the limit that the number of systems goes to infinity. This is another way of saying that the outcome X is bound to occur.

Contributors and Attributions

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