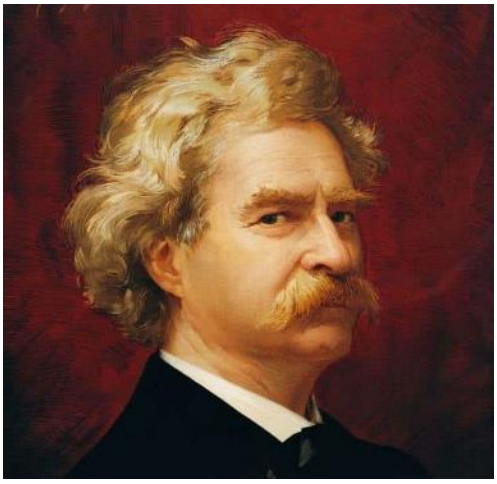
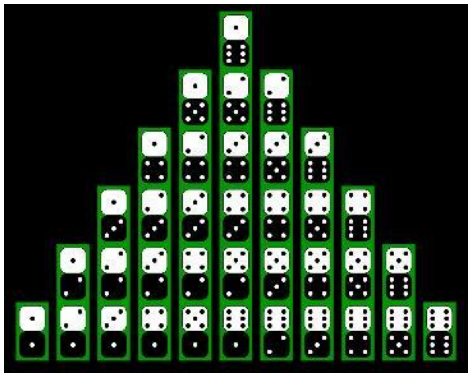
Not likely!



"There are three kinds of lies: lies, damned lies, and statistics." Mark Twain popularised this saying, which he wrongly attributed to Benjamin Disraeli. (The connection between lies and Prime Ministers is another subject that we won't explore here!) Statistics, with which our previous article finished, can certainly be misleading, either by deliberate misuse or because many people just don't understand it very well.

In mathematical terms, the probability of something happening or being true can be expressed as a number between zero (0), totally impossible, and one (1), a complete certainty; alternatively we can multiply everything by 100 to give a probability between 0 and 100%. When it comes to dice, throwing just one gives six possible results with equal probabilities of $^1/_6$. If you repeat this many times over, you expect to get the numbers 1–6 roughly equal numbers of times, but how nearly equal should they be and how much of a deviation should make you suspect dice loading? The answer depends on how many throws you've made and can itself vary if you repeat the whole experiment again. Statistics handles such questions with formal concepts like probability distributions, standard deviations, and confidence limits.



Throwing two dice together gives 36 possible pairs of numbers (6×6), the combined total ranging from 2 to 12. The eleven different totals aren't equally probable because there's only one way of making 2 and one way for 12, but 6 ways of making 7, which is the most likely total. So the probability distribution (flat) for the result of a single throw is different from that (with a central maximum) for two dice throws added together. Statistics recognises many different distributions, some of which occur often in scientific research, affecting experimental measurements and results calculated from them.

Here are some situations in which statistics are misused or misunderstood. The first is league tables for things like school exam and test results, university research assessment exercises, and hospital performance. A lot is made of positions in a league table and how they change from one occasion to another, annually or at other intervals. This concern ignores at least two factors that can seriously affect the meaning and value of such comparisons. The first is that the various contributions to the league tables involve putting numerical scores on things that aren't always precisely measurable, and usually no indication is given of the level of uncertainty in these numbers. So each "total score" that is given as a single number should really have what statisticians call a "confidence interval" around it, such as 56±3 to suggest the answer could easily range from 53 to 59. In most cases sensible confidence intervals (uncertainties in the scores) are considerably

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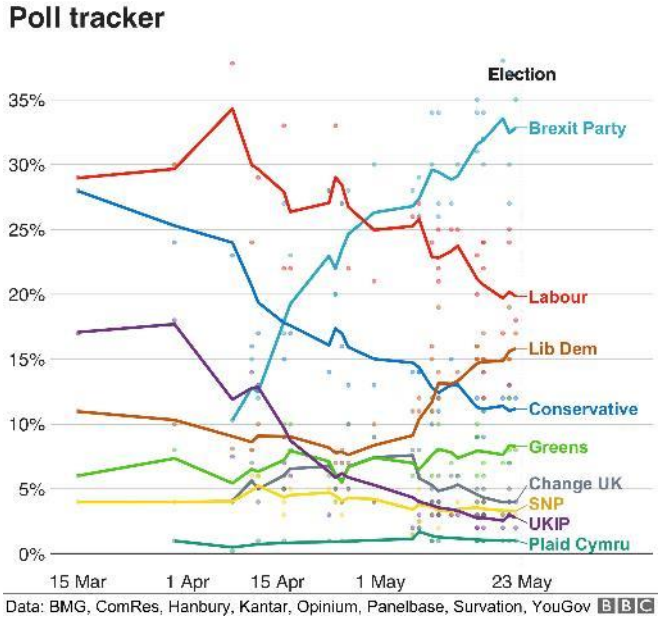
A-level results 2013: results from 400 state schools

The Telegraph's searchable school A-level results table shows the percentage of exam schools across the country.

A-level results 2013: results from 400 state schools

RANK	SCHOOLNAME	LOCATION	GENDER
1	Queen Elizabeth's	Hertfordshire	B
2	Tiffin Girls' School	Kingston-upon-Thames	G
3	Henrietta Barnett	London	G
4	Wilson's	Surrey	B
5	Altrincham Grammar for Girls	Cheshire	G
6	King Edward VI Camp Hill for Boys	West Midlands	B

larger than the differences in scores for whole wide ranges of positions in the table, so the positions themselves are really subject to quite large uncertainties. Secondly, judging criteria are often changed from year to year, so movements up and down don't necessarily reflect a real change in performance.



Similar criticisms can be made of opinion polls, or at least of the way they are reported and interpreted. The main problem here, quite apart from whether people are telling the truth when answering questions, is that an opinion poll surveys a small proportion of the entire population and is supposed to give the same result as if everyone were asked. Statisticians call this sampling a population (or distribution) and it's vital that the sample is genuinely representative if the results are to be valid. The size of the sample is also important: the smaller it is, the larger the uncertainties in the results. To be fair, the reporting of opinion polls before an election has improved in this respect in recent years, with explanations often given of the likely uncertainly levels and sample sizes, but small changes are still seized on by some of the media.

Extremes of probability – near-certainties and very tiny probabilities – are particularly prone to misuse, partly because most people struggle to understand extremely small and large numbers that have to be written in special notation such as 10^{82} which means 1 followed by 82 zeros, very approximately the number of atoms estimated to be in the observable universe. I'll give you just one example to end what's been a rather dry article this time – congratulations if you've stuck with it so far – and we'll look at some more misunderstandings next time in, I hope, a lighter vein. The first British astronaut, Helen Sharman, recently said "Aliens exist, there's no two ways about it. There are so many billions of stars out there in the universe that there must be all sorts of different forms of life." In a previous article we saw how the probability of extra-terrestrial life can be seen as the result of multiplying together the likely number of planets capable of supporting life (probably a very large number) and the probability of life existing on any one planet (an extremely small number). Helen Sharman has taken the first of these and ignored the second; for her, the result is essentially a probability of 100% ("no two ways about it"). I think her expertise in aeronautics is probably greater than her grasp of statistics (but I'm not going to put a figure on the probability!).

Bill Clegg

Modified version of the article in the Tyne Valley Express for January–February 2020