What eating chocolate, winning the Nobel prize and statistics have in common

Catch phrase for twitter:

Need an easy delicious way of upgrading your science career? #eatmorechocolate #winthe #Nobelprize

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Before you start reading this, we suggest you grab a chocolate bar.

Fun science fact, Dr. Franz Messerli, discovered a correlation between chocolate consumption and the number of Nobel Prize winners in several countries. The p-value associated with it was 0.0001, which is considered in science to be highly significant.

But before you devour your next chocolate bar, we should go into more detail about p-values. The p-value serves to measure the statistical strength and reliability of a hypothesis test. A hypothesis test includes a null hypothesis (H_0) - the outcome we are testing for - as well as an alternative hypothesis (H_1) - the negation of H_0. The p-value is a measure of the probability of the null hypothesis being true so the lower the p-value, the higher chance that the null hypothesis is incorrect. The rejection threshold is typically 0.05. However, the rejection of a null hypothesis doesn't always mean that you can blindly accept the alternative hypothesis.

To better in vision this strangely abstract concept of statistics, imagine your favorite restaurant claims that it takes them no more than 30 min to deliver their food, but you suspect that is takes longer. To check it, you do a hypothesis with H_0: The delivery time is less than or 30 min and the Alternative hypothesis: delivery time exceeds 30 min. You randomly collect some delivery times and run your data through the test. Like Messerli, you arrive at a p-value of 0.0001, which is less than 0.05. What does this mean? This means that

there is a 0.1% chance that the food arrives in under 30 minutes and you would proceed to reject the null hypothesis and conclude that the restaurant is lying to its customers.

How come such absurd theories, like Messerli's, get such significant p-values? Is all science ever published false?

Of course not. However, this should teach us to always take it with a pinch of salt, not believing anything just because it was published. Going back to Messerli's strange claim, the age-old relationship between causation and correlation comes into play. Winning the Nobel prize and eating chocolate might in fact correlate, but it doesn't imply causation. There are often other underlying complex causal relationships.

One error is that scientists rarely publish negative results which can sometimes be more telling than positive results. They fail to include it, fearing that it just an anomaly that will distort their data when in fact it might be very telling of the sample data. This way we also underestimate the fact that scientists are looking at thousands and thousands of correlations. Therefore, it is not that surprising that they will find once in a while such absurd ones.

Not to forget, study design: Multiple elements including sample size, error and bias can have an impact on the p-value. For example, a larger sample size will yield a smaller p-value even though the effect size stays the same. On the other hand, a sample size that is not large enough may not be an adequate representative and is more susceptible to random error.

However, we should not automatically conclude that the p value is completely useless; we have to look at the bigger scientific picture and attack it from different angles. For instance, you can measure the effect size using the tool of multiple regression, which describes the relationship between causation and correlation for each possible variable. Or you look at confidence intervals rather than hypothesis tests (estimated range of values which is likely to include the true one)

To wrap this up

What eating chocolate, winning the Nobel prize and statistics have in common should now be a little clearer -or maybe not so much. An accurate answer to this somewhat messy p value business would be: don't trust p-values alone; in examples such as this one, correlation cannot be translated into causation. As Messerli stated, eating more chocolate is correlated to a nation's wealth, as is high quality research, and consequently hosting a bigger number of Nobel laureates. Sorry to disappoint you, but the lesson here is to think about scientific research more critically. ***And no, eating another chocolate bar will not increase your chance of winning the Nobel prize***. But if it would help ease the frustration of finding out it won't, go ahead.

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