

The Guardian

The statistical error that just keeps on coming

Ben Goldacre

The same statistical errors - namely, ignoring the "difference in differences" - are appearing throughout the most prestigious journals in neuroscience

Fri 9 Sep 2011 15.59 EDT



We all like to laugh at quacks when they misuse basic statistics. But what if academics, en masse, deploy errors that are equally foolish? This week Sander Nieuwenhuis and colleagues publish a mighty torpedo in the journal *Nature Neuroscience*.

They've identified one direct, stark statistical error so widespread it appears in about half of all the published papers surveyed from the academic neuroscience research literature.

To understand the scale of this problem, first we have to understand the error. This is difficult, and it will take 400 words of pain. At the end, you will understand an important aspect of statistics better than half the professional university academics currently publishing in the field of neuroscience.

Let's say you're working on nerve cells, measuring their firing frequency. When you drop a chemical on them, they seem to fire more slowly. You've got some normal mice and some mutant mice. You want to see if their cells are differently affected by the chemical. So you measure the firing rate before and after applying the chemical, first in the mutant mice, then in the normal mice.

When you drop the chemical on the mutant mice nerve cells, their firing rate drops, by 30%, say. With the number of mice you have this difference is statistically significant, and so unlikely to be due to chance. That's a useful finding, which you can maybe publish. When you drop the chemical on the normal mice nerve cells, there is a bit of a drop, but not as much - let's say 15%, which doesn't reach statistical significance.

But here's the catch. You can say there is a statistically significant effect for your chemical reducing the firing rate in the mutant cells. And you can say there is no such statistically significant effect in the normal cells. But you can't say mutant and normal cells respond to the chemical differently: to say that, you would have to do a third statistical test, specifically comparing the "difference in differences", the difference between the chemical-induced change in firing rate for the normal cells against the chemical-induced change in the mutant cells.

Now, looking at the figures I've given you here (for our made up experiment) it's very likely that this "difference in differences" would not be statistically significant, because the responses to the chemical only differ from each other by 15%, and we saw earlier that a drop of 15% on its own wasn't enough to achieve statistical significance.

But in just this situation, academics in neuroscience papers routinely claim to have found a difference in response, in every field imaginable, with all kinds of stimuli and interventions: comparing younger versus older participants; in patients against normal volunteers; between different brain areas; and so on.

How often? Nieuwenhuis looked at 513 papers published in five prestigious neuroscience journals over two years. In half the 157 studies where this error could have been made, it was. They broadened their search to 120 cellular and molecular articles in Nature Neuroscience, during 2009 and 2010: they found 25 studies committing this fallacy, and not one single paper analysed differences in effect sizes correctly.

These errors are appearing throughout the most prestigious journals for the field of neuroscience. How can we explain that? Analysing data correctly, to identify a "difference in differences", is a little tricky, so thinking generously, we might

suggest that researchers worry it's too longwinded for a paper, or too difficult for readers. Alternatively, less generously, we might decide it's too tricky for the researchers themselves.

But the darkest thought of all is this: analysing a "difference in differences" properly is much less likely to give you a statistically significant result, and so it's much less likely to produce the kind of positive finding you need to look good on your CV, get claps at conferences, and feel good in your belly. Seriously: I hope this is all just incompetence.

. This article was amended on 13 September 2011 to make clear that the Nieuwenhuis study looked specifically at neuroscience papers, not psychology research.

As 2019 begins...

... we're asking readers to make a new year contribution in support of The Guardian's independent journalism. More people are reading and supporting our independent, investigative reporting than ever before. And unlike many news organisations, we have chosen an approach that allows us to keep our journalism accessible to all, regardless of where they live or what they can afford. But this is only possible thanks to voluntary support from our readers - something we have to maintain and build on for every year to come.

At the Guardian, we believe that access to trusted information is a right that should be available to all, without restriction - independent reporting, distributed fairly, accessible to everyone. Readers' support powers our work, giving our reporting impact and safeguarding our essential editorial independence. This means the responsibility of protecting independent journalism is shared, enabling us all to feel empowered to bring about real change in the world. Your support gives Guardian journalists the time, space and freedom to report with tenacity and rigor, to shed light where others won't. It emboldens us to challenge authority and question the status quo. And by keeping all of our journalism free and open to all, we can foster inclusivity, diversity, make space for debate, inspire conversation - so more people, across the world, have access to accurate information with integrity at its heart. Every contribution we receive from readers like you, big or small, enables us to keep working as we do.

The Guardian is editorially independent, meaning we set our own agenda. Our journalism is free from commercial bias and not influenced by billionaire owners, politicians or shareholders. No one edits our editor. No one steers our opinion. This is important as it enables us to give a voice to those less heard, challenge the powerful and hold them to account. It's what makes us different to so many others in the media, at a time when factual, honest reporting is critical.

Please make a new year contribution today to help us deliver the independent journalism the world needs for 2019 and beyond. **Support The Guardian from as little as \$1 - and it only takes a minute. Thank you.**

Support The Guardian



Topics

- Science
- Opinion
- features