A Rough Guide to TYPES OF SCIENTIFIC EVIDENCE

by Compound Interest (Andy Brunning) April 9th, 2015

You might think science is science, but some evidence is ranked higher by the scientific community than others, and having an awareness of the hierarchy of scientific evidence can help you sort the science from the pseudoscience when it comes to various internet claims.

This article was inspired by a couple of things this week. The first was the recent Gawker article on the Food Babe's spurious chemical claims, which you may well have seen spreading like wildfire through social media earlier this week. The second was a Twitter exchange regarding the artificial sweetener aspartame, during which the user with whom I was conversing repeatedly linked me to poor quality 'evidence' in order to try and prove their point.

What I took away from both of these situations was that some people aren't sure what counts as robust scientific evidence. To an extent, you could argue that this is a fault in education. We spend a lot of time discussing the scientific method with classes – the concept of a fair test, controlling variables, repeating experiments, that kind of thing – but we rarely talk about sources of scientific evidence.

Levels of scientific evidence is a complicated concept, but it's of great benefit to understand, even for people who aren't destined for a scientific career. The idea that sources of internet misinformation like the Food Babe might cease to exist with a better public understanding of levels of scientific evidence is idealistic, but better public understanding of levels of scientific evidence might make people question the quality of evidence provided, rather than accepting it at face value.

The first point to make is that the types of scientific evidence aren't always distinct, and even if one type of evidence is lower in the hierarchy that doesn't mean it should instantly be disregarded. In fact, some of 'lower' types of evidence can be precursors to the more conclusive (and 'higher') types of evidence. For example, medical trials of potential drugs will usually start with animal or cell trials, before then progressing to randomized controlled trials. When enough randomized controlled trials have been carried out, a systematic review of these trials becomes possible. Thus, the amassing of scientific evidence is an ongoing process, often involving several types of evidence.

Before discussing the two primary types of evidence, it's worth discussing the outlier: Anecdotal evidence or someone's gut feelings or opinions. An example of anecdotal evidence would be someone relating a tale of how they experienced a reaction after ingesting a particular type of food or medication. While anecdotal evidence can act as a precursor to scientific investigation, in isolation anecdotal evidence is often considered dubious.

Perhaps surprisingly, an expert opinion on a particular topic is considered to be at lowest level of evidence. Of course, if references to other, more rigorous scientific studies are provided as part of the opinion, it can help, but it's still best to go to the source of the evidence in these cases. Experts' opinions aren't always vetted, so whether published in a letters page, or merely online, they must be judged with this in mind. I could write that a particular chemical will turn you into a newt, but unless I can provide a link to scientifically rigorous evidence that backs up my opinion, it counts for next to nothing.

Case reports, used particularly in a health context, merely observe particular individuals and comment on their condition. Case reports (or case studies) cannot prove that a certain treatment or exposure causes a certain effect, but they can reveal areas for potential further investigation. A case-control study, on the other hand, works backwards. To give an example from a medical context, a case-control study will involve two group of patients, some with a particular symptom or disease, and some without. Researchers then look backwards in time to try to ascertain a common exposure or attribute that could have caused the symptom or disease in the patients who have the disease but not the patients who do not have the disease.

In a cohort study, one or more groups (cohorts) of subjects are studied over a period of time. Cohort studies can either be cross-sectional or longitudinal. Cross-sectional studies collect and analyze data from different cohorts of subjects at the same point in time, whereas longitudinal studies collect and analyze data from the same cohorts of subjects at different points in time. Longitudinal studies are more commonly used in psychology and sociology than in the other sciences.

Experimental studies generally appear higher up the hierarchy, with one exception: animal studies and *in vitro* (or cell) studies. Animal and *in vitro* studies rank lower, at least when considering human effects, because they are only models of what goes on in humans. In drug trials, animals may respond to a drug differently than humans; even in studies involving human cells in isolation, the effects may not be the same as they are in the full body. As such, animal and *in vitro* trials are usually precursors to studies in humans, if those human studies are deemed appropriate.

In a typical randomized controlled trial, subjects are randomly placed in a group; one group will receive the treatment, while the other will receive a placebo that appears identical. In the best trials, neither the subjects nor the researchers know which group they have been assigned to, as this helps minimize any potential bias. A control group is important, but is sometimes not possible. For example, in trials of vaccines, it would not be ethical to withhold vaccines from those suffering from potentially deadly diseases, and instead give them a placebo.

At the peak of the scientific evidence hierarchy are meta-analyses and systematic reviews. Systematic reviews collate all high quality research on a topic, particularly that provided by randomized controlled trials where available. Meta-analyses also collate other research studies and use a statistical technique to evaluate the strength of the effect across the entire set of studies. For this reason, meta-analyses can reduce bias, intended or otherwise, in independent studies, and give a more balanced picture.

In conclusion, different forms of scientific evidence exist. Being aware of each of them is a useful tool in interpreting scientific evidence, and making sense of claims in the media and elsewhere.