How To Read a Scientific Article

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A Note to the Reader

This article was written originally for antiagingadvances.com, which I will be starting sometime in the near future. As such, it was written with that audience in mind. However, it is relevant to you if you want to start using intelligently some of the less conventional treatments for ADHD that are now available. My hope is that this article will help you to better understand the scientific process, so you can evaluate all the health related claims that are being thrown around today.

How to Read a Scientific Article

The Scientific Method

Science begins with observation and description. The scientist examines the world around him and tries to develop an explanation for what he observes. Often, a researcher may do experiments just to see what happens. After gathering all the results, the scientist tries to develop a hypothesis, or model, of what he believes best fits the data. Based upon this model, he will then make predictions of what ought to happen and experiments to see if his predictions are correct. As more and more supporting evidence is gathered, the hypothesis eventually becomes known as a theory and eventually a law. Thus, Einstein's Theory of Relativity, which began as a hypothesis in his own mind, has traveled the gamut of hypothesis to theory and is now considered a law by most physicists.

The Problem

All that is good for straight scientific research on physical phenomenon. When dealing with health issues there are other complicating factors that make using the unadulterated scientific method difficult.

To properly test a human health related hypothesis, you need research subjects. That means people. You have to get volunteers or paid subjects to agree to be part of the experiment. Here you run into some problems. In animal research, it is not uncommon that one test group does better than the other. Frequently, the goal of the research is to determine just that, which group does better, A or B?

Let's say you want to find out the relationship of a certain virus to cancer. In animal studies it is possible to take one hundred rats, infect fifty of them with the virus, and compare the incidence of cancer in each group. It is not so important to us that we may be causing the rats in the test group die of cancer.

You can't do this with people. Even if you could get enough subjects for the study, which you probably could if the price was right, it is just not ethically acceptable to shorten the lives of people to prove a theory. It might be good scientific method, but it's not good science.

The second problem with testing on humans, which is particularly significant when studying life extension, is that we live too long. Not that this is inherently a problem. Longer and better life is actually our goal. The problem lies in that to conclusively test whether or not a certain treatment will extend life, you have to wait until all the subjects in your experiment die. That means if you want to determine whether or not a certain nutrient will lengthen people's lives, say by 10%, you have to wait 80 plus years until all the subjects die. This is impractical. Most of the time, the best we can do is extrapolate from animal studies or do short term controlled studies on humans.

There is another problem with human studies. Humans have a wonderful gift, called the mind. It's what makes us human, allows us to experience emotions, reason abstractly, and communicate with one another. It also allows us to have expectations. These expectations can influence the results of scientific research.

This is called the placebo effect. It attests to the power of expectations to influence perception. It is a factor in human research. It's hard to determine if a certain drug is effective when most people will notice improvement just because they are taking something that they think will help.

For this reason, well-designed human experiments are performed in a double-blind fashion. That means that neither the researcher nor the subject know if the subject is getting the real drug or a fake. We then compare the results of the real group to the fake group and see which group on a whole does better. Any human experiment that is not double-blinded is open to question as to its validity.

The Placebo Effect

Here is an example. If you give 100 patients suffering from pain an injection of morphine, most will experience some relief. What if you inject water and tell them that it is morphine? Up to 75% will experience pain relief, also. 40% will experience significant pain relief, just as if they received morphine.

Unfortunately, the double-blind design is not always possible in human research. For example, if you want to test the efficacy of lung resection on cancer, you can't bring your control group patients to surgery, open them up, and then pretend to remove their lung just to eliminate the placebo effect. In human health research there is a limit as to how well we can design the experiment.

Pre-existing Concepts

All that has been said so far deals with the ideal experimental setting, in which the researcher is interested only in finding the correct answer. In practice, however, there are occasionally other factors that influence the accuracy of research.

Scientists, like everybody else, like to eat. They also want to be recognized as knowledgeable and successful. Most of all they, want to keep on being scientists. With that in mind they have to be very careful what results they publish. If there is a particular idea that enjoys the consensus of the leading authorities and of those who fund research, someone who publishes results that challenge this idea, might find it hard to get his next research grant.

Pre-existing beliefs are not a new problem. Socrates had his life shortened for viewing things somewhat differently than the ancient Greek establishment. Galileo was brought before the inquisition and died in prison for supporting the idea that the sun, and not the Earth, was the center of the solar system. If you are a Socrates or a Galileo, you might be willing to stand up to defend the truth. Most scientists prefer not to die or be ostracized for their discoveries. Even Einstein, who was by no means concerned with popular opinion, once fudged his results because he couldn't accept that his equations allowed for the existence of black holes.

Economic Influences

There is another factor that will affect what you read in health literature. This applies to any popular and lucrative field. Since my interest is longevity, I shall discuss it in these terms.

Life extension has always been the an arena for faddists, charlatans, mock scientists, and the misinformed. When you start looking into what works to extend and improve life you'll find wonderful testimonials that support about anything you can imagine. There is always someone who will make any somewhat tangible claim and then market it.

The scientific community has reacted very strongly to counter this problem. The official party line is that nothing helps to extend life. This conservative, bordering on reactionary, approach does not benefit anybody. The result is there are two sides of the life extension debate, the miracle criers and the naysayers. Neither one base their assertions on real evidence. Other Problems with Studies

There are a number of other factors, which influence the validity of scientific research.

Who Funded the Study?

Many studies are funded by corporate sources. If you read enough scientific literature you will probably notice that most of these studies find results that are favorable to their corporate sponsor. This probably is not a coincidence. Corporations don't fund scientists that prove that their products that are harmful.

Even government-sponsored studies are not free of bias. There are often political factors that will affect what are considered acceptable results. I would suspect that much of the proof that indicted cigarette smoke to be a serious health hazard did not come from studies funded by the state of North Carolina.

The take home message is that when you evaluate a study you should know who is paying. The one who is holding the purse strings also may be holding the puppet strings.

There was recently a 20 year, multi-million-dollar study done at a number of medical centers including the Department of General Child Psychiatry at Massachusetts General. The purpose of the study was to determine the effect of nutrition on school performance. Their conclusion: "Results of this study suggest food insufficiency and hunger is associated with poor behavioral response and academic functioning." In other words, if a child eats breakfast he will do better in school. So who funded this study? The Kellogg's Corporation and the Milk Marketing Association.

Researcher Bias

This is a corollary to the funding question. Most scientists do not fake data. Usually they fix up the problems in their analysis. This is done in subtle ways. A researcher may emphasis one result more than another. He might stress a point that his data doesn't really prove or ignore another possible explanation for what his results show. That is why you can't always rely on the abstract or the discussion section in research papers.

How Bias Affects Medical Decision Making

I'll give you an example of how bias plays a role in medicine. Recently, I was involved in a case concerning a kidney transplant.

Kidney transplantation is major surgery. The donor spends many hours on the operating table and has a long and painful post-operative recovery period. After surgery, the donor spends many weeks incapacitated and is left with a very unsightly surgical scar.

In the past decade, surgeons at Johns Hopkins in Baltimore have pioneered a new and elegant surgical technique. Under laparoscopic guidance, the surgeons operate through a series of small incisions to remove the donor kidney. The result is that there is much less trauma to the donor. The recovery period is cut in half, the degree of blood loss and postoperative pain are greatly reduced, and the scarring is minimal.

However, there are some negative considerations. The surgery is much more difficult technically and requires a surgeon who is very experienced in laparoscopic surgery. Critics of the procedure claimed that rejection was more common with this approach. They also feel that, since the surgeon had a limited operative field, the risk of serious complications during surgery is much greater.

The transplant surgeon in my case was willing and able to do either procedure. He left it up to the donor and recipient to decide which approach to use. I was very close to both the donor and the recipient. It fell upon me to decide which is the better technique.

Upon examination of the research one thing became very clear. There was a great deal of controversy. Both sides, pro and con, had very strong opinions. Both sides had data that irrefutably proved that they were correct. Another thing became quite clear. There was more going on than just a pure scientific dispute.

The biggest proponents in favor of the new laparoscopic technique were the surgeons who designed the procedure. They had designed the procedure with a certain goal in mind.

There are far more patients awaiting kidney transplant, than there are willing donors. It is difficult to be a kidney donor. In addition to the fact that you are giving up a healthy kidney, which you someday might need, you are agreeing to undergo a very long surgery with a long and painful recovery period. It may be several months before you can resume

a normal life and go back to work. And you are not even the one who is sick! The result is that many possible donors for physical and financial reasons cannot undergo surgery. The doctors at Johns Hopkins designed the new procedure to address this problem. They felt that if the operation was a less traumatic procedure and the recovery period was shorter, more people would be willing to part with their healthy kidney. They published data to show that this new procedure has results equal too or better than the standard kidney procedure.

The opponents argued that the new procedure was not as good and they published results to prove it.

What was the motivation of each side? The developers had their careers at stake. They also had an altruistic motivation; that is, to solve the problem of lack of kidney donors. Who were the opponents? It turned out that none of the transplant surgeons who opposed the new procedure were laparoscopic surgeons. That means that they were unable to use this new technique. If this technique were to become standard procedure, they themselves would no longer be able to transplant kidneys.

Each side had irrefutable data to prove that they were correct. How did they do this? They didn't make up the data. They chose which data to include in their analysis.

Kidney transplant surgery has been performed for almost 40 years. Originally, there were some serious complications. Now the technique has been so refined that the complications are minimal. Although this is still a major surgery, the results are excellent. The donor still has all the post-operative problems that I have mentioned, but these are an expected outcome of the surgery. They are not technically listed as complications.

What did the developers of the new technique do? They compared the results of laparoscopic approach to all 40 years of traditional transplant surgery. And guess what. The results of the new procedure were better. Why? Because they were including in their comparison surgical techniques that have been outdated for decades.

How did the opponents to the new technique get their results? Exactly the same way! The laparoscopic approach was a relatively new procedure. Physicians have refined and improved the technique over the course of a decade until they developed the technique that is used today. The opponents to the technique included in their data analysis the

entire history of the laparoscopic technique, including the early years when the procedure was still in development. And guess what. The standard approach was better.

What I had to do was reanalyze the data, taking the results from the cases using the current laparoscopic procedure and comparing it to the results using the current standard technique.

The conclusion: The results of both techniques are excellent. The standard procedure is slightly better than the laparoscopic approach, but not enough to warrant the post-operative problems for the donor. I advised the donor and recipient to opt for the laparoscopic approach. It's now two years after surgery and both are doing fine.

This analysis took me two weeks. I do not do it with every series of articles I read. Nor should you. The point you should realize is that whenever you come to a controversy in health literature, you should analyze the motivation of each disputant. You will find it rare, that the actual facts play a significant part in the reason for the dispute.

What You Can Do

Thus we have a number of reasons, technical, practical, economic, and emotional, why the results of the article you read may not be accurate. What we need to do is to find clarity in this hodge-podge of dogmatism. We shall try to go point by point to do this. You have to have an understanding of what constitutes evidence to get any benefit from the amazing amount of research that is being done.

Is This a Scientific Article?

The first thing you must decide is if what you are reading is really a scientific study, an interesting story, or a glorified sales letter. To do this you must understand what constitutes scientific evidence.

Types of Evidence

There are four categories of evidence used in scientific literature: Testimonial, Argumentative, Correlational, and Experimental

Testimonial Evidence

These are anecdotal reports. Someone says, "This worked for me." This is the most popular form of evidence used.

"We gave such and such herb to our patients with condition x and they all said they felt better within a week."

"Everyone says Bach drops really work."

Another example used by a certain New York based diet doctor:

"My 60,000 satisfied patients that have come to my clinic prove that my diet works."

The problem with testimonial evidence is that it is impossible to evaluate. It never includes people who the treatment didn't help and it never includes those who got better without the treatment. The other problem is that it is impossible to quantify. The diet doctor who I mentioned has sold millions of books. Therefore, if 6 million people tried the diet and only 60,000 lost weight, that's 1% success rate. Pretty lousy. Is that what happened? Maybe yes, maybe no. Does his diet work. Maybe yes, maybe no. There is no way to tell.

Therefore, testimonial evidence, although it is used for everything and by everybody, is basically worthless. After all the reports and testimonials there is no way to evaluate objectively if it there is truth to what is being reported.

Argumentative Evidence

The next level up from testimonial evidence is argumentative evidence. This is taking all known facts and experimental data and formulating a hypothesis that something ought to be.

An example:

We know that oxidation and free radicals damage cells on the molecular level. We know that aging is associated with molecular damage. Therefore, it follows that by taking antioxidants and free radical scavengers, like vitamin E, vitamin C, and selenium, we can prevent or retard aging. This is a very plausible argument. Is it true? It could be, but you have to test it.

Actually, antioxidants have been tested. They have been shown to do wonderful things for preventing disease and extending relative life span. They have demonstrated no benefit at all in slowing the aging process. Argumentative evidence is one level better that testimonial evidence. That makes it next to worthless.

Correlational Evidence

This actually has some scientific validity. Correlational evidence is based upon the fact when two things frequently occur together, there is a direct and possibly causative relationship between them, or else they may be caused by a third factor. For example:

Observation A: When the wind blows people with hay fever get sick.
Observation B: When the wind blows the pollen count goes up.
Conclusion: It could be pollen is related to or the cause of hay fever.

Is this concrete proof? No. I can make a different argument.

Observation A: When the wind blows people with hay fever get sick.
Observation B: When the wind blows the barometric pressure goes up.
Conclusion: Rise in barometric pressure causes hay fever. In terms of correlation the evidence is the same. But one analysis is true and one is not.

Experimental Evidence

This is the only evidence that is accepted as proof. Someone does an experiment controlling all factors in two separate, but identical groups. In the experimental group the researcher varies a single factor, which he does not do in the other group. This causes a certain result. Other testers at other locations then repeat this experiment and they get the same result. This constitutes experimental evidence and is the closest we come to proof.

For example:

You give 500 rats pneumococcal pneumonia. You divide the rats into two groups. To Group A you give Penicillin. To Group B you do nothing.

The results:

In Group A: All the rats survive and are better in 5 days.

In Group B: 100 rats die and 150 get better after two weeks.

Conclusion: This would constitute proof the Penicillin is an effective treatment for pneumococcal pneumonia, at least in rats.

What Does All This Mean?

How can you use this knowledge to understand what you are reading? First, you should recognize which type of proof is being provided. If the evidence is based on controlled studies, or is correlational, what you are reading may have a scientific validity. If it is a lesser form of evidence; it probably makes very good fictional reading and should be treated as such. Does that mean that it is wrong? No. Historical novels also have much accuracy. However, accuracy isn't the primary concern of the author. That is why you will find these novels in the fiction section of the library. Most health articles belong in the same section.

How Do You Evaluate?

Let's say you have an article about something and you wish to evaluate its validity. How do you do this?

Who is Reporting the Study

Where are you reading the article? Is it in a scientific journal, a scientific magazine, the Reader's Digest, or the National Enquire? Each one has its own particular bias. Hopefully, scientific journals are the best source of true scientific research. They are only as good as the scientist who is reporting and the editors who edit, but at least the intention is to give an accurate account.

Popular science and health magazines are the next level down. The advantage of these magazines is that they present the material in a way that the educated layman can understand. The problem is that the writers usually do not have the sophistication or the inclination to evaluate the primary sources of information. Their concern is selling their articles. Their goal is to get you to read the article and say "Wow" when you are finished.

If the study that is presented is a well-controlled unbiased study, and the researcher gives an unbiased conclusion, then these popular science magazines are a good source of information. Before you adopt a major change in your lifestyle, however, you should investigate their sources. Either go back to the primary article yourself if you feel you can evaluate it, or bring it to a physician or scientist that you trust and ask for his opinion. Believe me, you will be doing your doctor a favor. He probably hasn't read that article and it's important for him to know what the popular press is saying.

Reader's Digest is a wonderful source of practical advice. It is probably more useful than most popular science magazines. And I am not just saying that because they gave me a scholarship. Yet the same concerns apply. The authors are trying to sell and often lack the sophistication to evaluate the evidence of any study. You must check if the information is accurate.

The National Enquirer: You would be surprised how many people get much of their information about the world from magazines like the National Enquirer. Don't be one of them.

Who Did the Research?

The value of a research paper can often be determined by who conducted the study. Here are a couple of things to consider:

Is the Researcher a Scientist or a Salesman?

Is the person who wrote the article in business selling the product of his research? If so it may cost him his livelihood if his research comes up with an unfavorable conclusion. He will certainly not publish an unbiased report and he will most likely hide damaging evidence. Does this mean what he is saying is wrong? Of course not. It means that you can't rely on his conclusions and you have to examine his experiment very carefully. Outside verification from other researchers are often needed to support such studies.

Who Funded the Study?

Most researchers want to stay in research. Very few will publish a study that proves the company funding their study produces ineffective or harmful product. Again, this doesn't mean the study is wrong. It just means you need verification from other sources before you can rely on such a study.

What Type of Evidence is the Researcher Using?

As mentioned before, you should know what type of evidence is being presented to you. Even in the finest medical journals, not everything publish is a scientific study. Sometimes physicians publish "Case Studies." These are basically anecdotal reports and have minimal scientific validity.

An excellent example of how a case study was misused is the story of how vitamin C became associated with kidney stones. For many years, the medical literature published that taking large amounts of vitamin C may cause oxalate kidney stones. An article in the 1984 edition of *Nutrition Reviews* stated, "vitamin C may be associated with the formation of oxalate stones." The article cited seven references to support this assertion. Upon examination, six were secondary sources which all referred to a letter appearing in a 1979 issue in the British medical journal, *Lancet* as the primary source. In this journal the author of the letter stated that he found one of his patients had excess oxalate crystals in his urine. This patient also took 4 grams of vitamin C every day. The author theorized that excess vitamin C might cause oxalate kidney stones. The patient in question did not have oxalate kidney stones. In fact, there is no record of any patient having oxalate kidney stones as a result of taking vitamin C. Yet because this letter appeared in a prestigious journal and others took it at face value without examining the evidence properly, this incorrect idea held sway in the medical community for almost two decades.

Is the Data Being Used Properly?

Does the data support the conclusion

Most researchers will not fake their data. If the conclusion is one that causes a problem, a scientist will consciously or subconsciously interpret it in a more favorable way. He may selectively include or exclude data in a way to get a more desirable result. Try to look at which data is excluded and which data is used. Always think if there is another way to interpret the results.

Other Warning signs

Is the Message Being Presented Emotionally Laden?

If so, someone is getting something out of it. This is usually money or prestige. Either way you should seek independent verification for anything presented. If you feel emotionally affected by what you are reading, be careful. You might have in your hands a very well disguised commercial.

Does the Author Have an Ax to Grind?

This is a fairly common problem. Certain researchers find themselves with unpopular positions. If they pursue their ideas, the scientific community often censures them. Such researchers are understandably bitter and very often loose their objectivity. This will be apparent in their writing style. This does not disqualify what they have to say, but it is a warning that you need to evaluate the assertions.

Conclusion

I understand that this is a lot to think about. It actually isn't as hard as it sounds. The main thing is to be aware of the possible problems with any scientific article and not be swayed by emotional jargon. If you have any questions you should be able to bring them up with a health care professional that you trust. If you wish, you may ask me. I will try to help in any way possible.

Good luck.

Anthony Kane, MD

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