

Top Ten Impediments to Understanding Science

Debra S. Schroeder, Ph.D.
Psychology Department
The College of St. Scholastica

1. **Vividness effect:** Events that stand out in our minds have more influence on our beliefs about the world than statistics and graphs. Risk assessment provides some good examples. Some people are terrified to fly, but think nothing of crawling into a car and driving an equal distance. This, despite the fact that flying is much safer. But, vivid reports of one large airplane crash stand out in our minds more than the 3 to 4 people killed per car crash which actually adds up to more people mile for mile. Anecdotes also draw on the power of the vividness effect. For example, despite the fact that research has been unable to link vaccines and autism, vivid anecdotes continue to sway the beliefs of many in the general public that there is such a connection.
2. **Correlation vs. causation:** Two events are correlated when one can be used to predict another. For example, abortion relates to breast cancer. However, this connection does not rise to the level of causality unless: the “cause” precedes the “effect” AND manipulating the “cause” changes the “effect” AND no other factor could have been responsible for the “effect” other than the “cause.” To test for causality, we do experiments in which an independent variable is manipulated first to see whether it affects the dependent variable. We rule out “other” factors through experimental control (e.g., same testing situations) and random assignment. In the “abortion causes breast cancer” example, while abortion did precede breast cancer, the other criteria were not met. Whether or not women had abortions was not manipulated, they were not randomly assigned to groups, and there were other factors that could have been responsible for the differences in breast cancer rates. In fact, it later was determined that the likely reason for the differential rates of breast cancer was because women who were being treated for breast cancer produced more comprehensive medical records, especially those related to reproductive experiences like abortion.
3. **Confirmation bias:** This is the tendency to see what we already believe to be true. If I believe that “distance makes the heart grow fonder,” I’m going to notice instances of long-distance relationships that last and not the other 3 cells:

	Relationship Outcome	
	Stayed Together	Broke Up
Far Apart	X	
Distance		
Close Together		X

X = cells representing confirmation bias

4. Person-who statistics: A scientific finding is given, and a person dismisses it, citing a “person who” went against the finding. In social psychology, we like to look at maxims like “birds of a feather flock together” versus “opposites attract.” I trot through the research citing study after study indicating that the former is true, and a student raises her hand saying that she has a friend who is the complete opposite of her boyfriend. “How do I explain that?” she wants to know. I point to the fact that much of science is probabilistic—it represents general rules. These general rules may not apply to every case, but that doesn’t mean the general rule is wrong. That’s like throwing out the idea that aspirin helps with headaches because one person isn’t helped.
5. Failure to appreciate coincidence: Two people in a room of 30 have a birthday on the same day. A gambler wins 8 in a row and believes he’s on a hot streak. You think about your friend and she calls. The odds of two people in a room of 30 having the same birthday is 71%. Chance processes over the long run do not always look like chance processes in the short-term. Given the number of events in the world and the number of thoughts an individual has in a given day, it’s not surprising that sometimes they overlap. Science, with the help of statistics, helps to rule out coincidence so that when a connection is “real” we know it, and when it is chance, we know that, too.
6. Statistical significance versus practical significance: When I ask my Statistics students at the beginning of the semester what “statistical significance” means, they say that it means “important.” I then explain that this isn’t at all what it means: it means that the results are likely not due to chance. And, effects not due to chance might not be very important at all. This is perhaps best illustrated in some research I did in graduate school examining the relationship between self-esteem and drug use. There is a statistically significant relationship between the two. Because of such data, drug abuse/use programs in the 90s made building self-esteem the cornerstone of their interventions. However, I did a review of the research and calculated indices of “effect size” that are commonly accepted as indicating practical significance. The most typical effect size index ranged from 1-5%. This means that, at best, self-esteem differences account for 5% of the variability of the differences in drug use. 95% of the differences were accounted for by something(s) else.
7. Lack of understanding of the dynamic nature of science: In science, theories pull together and explain a series of observations, as well as suggest hypotheses about future observations. Sometimes the hypotheses derived from the theory don’t pan out and the theory needs to be modified. Sometimes a scientific finding will be published, but researchers can’t replicate it, or they discover an alternative explanation. Then, theories, conclusions, and implications need to be modified. Scientists accept this as how science works, but often the public sees this as being wishy-washy. “First they said to eat butter and now they say not to. They don’t know what they’re talking about. I’m just going to do what I want.”

8. Failure of scientists to communicate their research findings in understandable terms: It's hard, but extremely important to do because the public funds our research, it has tremendous potential to shape public policy, and scientific literacy among our citizens is important.
9. Failure to appreciate the importance of the placebo effect: Often, I will start out my classes by asking students to design a study to test a research question I give them. For example, I might ask them to determine whether the nursing practice of manipulating the energy field over a patient can reduce pain. Often, I will get an answer like, ask them to rate their pain before the treatment and then after the treatment. If the pain declines, the treatment works. However, without a control group who experiences all aspects of the study except for the treatment, there is no way to rule out the placebo effect. Maybe the treatment worked because the patient thought the treatment would work. Might someone in the room not moving their hands in a way that "manipulates the energy field" also work?
10. Inability to differentiate an expert from a non-expert: Reliance on an expert is not always the wisest thing to do, but none of us can know everything. We rely on accountants to do our taxes, doctors to treat our ills, geneticists to unravel the secrets of the human genome. But almost no science is free of its pseudoscience (for us it's parapsychology, but there's astrology, reflexology, numerology, etc.), its quacks, or its unqualified practitioners. For example, most of you have heard of Dr. John Gray, who wrote Men are from Mars, Women are from Venus, but many of you may not know that he is not a scientist in the area of relationships. His Ph.D. was from an unaccredited institution called Columbia Pacific University that involved many correspondence courses. After an investigation of the legitimacy of its programs, its doors were closed as basically a degree mill. He is not licensed to practice psychology, but rather spiritual counseling in California due to his 9-year stint as a monk in Switzerland. He has done no systematic research of couples, although his Mars-Venus books have made him a fortune. Dr. John Gottman, on the other hand, received his Ph.D. from the University of Illinois. He has observed over 760 couples and written at least 109 journal articles. His research includes signs to look for in troubled and happy marriages, and with his systematic research of verbals and nonverbals during discussions about controversial marital topics, he can predict which marriages will succeed and which will end with over 90% accuracy.