SECTION FIVE

WHY DO BRILLIANT PEOPLE BELIEVE NONSENSE?

BECAUSE THEY BELIEVE
"LIES, DAMN LIES, AND STATISTICS"
(With credit to Mark Twain)
CHAPTER 16

THEY FAIL TO CLOSELY EXAMINE STATISTICS

"They've done studies, you know. Sixty percent of the time it works every time."

— From the Film "Anchorman"

A Crisis We Must Avert

According to the US Department of Education, we've got a crisis on our hands. I'll let the below U.S. government web page explain.¹

The United States has become a global leader, in large part, through the genius and hard work of its scientists, engineers and innovators. Yet today, that position is threatened as comparatively few American students pursue expertise in the fields of science, technology, engineering and mathematics (STEM)—and by an inadequate pipeline of teachers skilled in those subjects. President Obama has set a priority of increasing the number of students and teachers who are proficient in these vital fields.

![Projected Percentage Increases in STEM Jobs: 2010-2020](image_url)

**The need**

Only 16 percent of American high school seniors are proficient in mathematics and interested in a STEM career.

[expand/collapse]
It's difficult to overestimate the importance of this issue. Those who act on these statistics make decisions and implement policies that impact all of us.

- The government plans to allocate hundreds of millions of our tax dollars (340 million dollars budgeted for 2015) into initiatives that will help to churn out more and better STEM teachers and students.²

- We urge our children to pursue these fields, in order to save America and take advantage of a huge growth industry, even if their interests and innate talents may suggest other fields.

- We must necessarily de-emphasize certain skills and subjects (less diversity of high school course offerings, less time put into other subjects) in order to prioritize the crying need of the day.

With this background, it's no wonder that when CNN surveyed the job market in 2012, they chose Biomedical Engineering as #1 in the list of the "Best Jobs in America."³

A Deeper Look at the Crisis

There's no doubt that we want to produce great scientists and offer the best opportunities in science to our students. I love science and enjoy math! And nobody doubts that we should always pursue ways that we can tweak our education to inspire the next generation of scientists.

But statistics can be confusing, leading us to make poor decisions. In order to better understand this chart and the looming crisis, let's dig a bit deeper into the data that forms the foundation for these claims. This will serve as an example case in examining statistics.

1. Understand exactly what the chart is measuring.

In this case, note that the percentage increase doesn't tell us how many jobs will be available in this field.

Look back at the chart, focusing on biomedical engineers, since it's the most dramatic stat. A cursory glance tells us that 62 percent of all jobs in 2020 will be biomedical jobs. Compare that to only 16 percent of high school grads interested in a STEM career and the outlook seems
bleak indeed. Surely we need to motivate tons of students to study biomed!

But that's a misreading of the chart.

One tip-off that we've misread it is that if we add up all those percentages, they come to well over 100 percent, showing that the chart must not be talking about percentages of available jobs at all. In fact, the graphic tells us in the title that it's charting the percentage increase, not the number of jobs.

Think of percentage increase in this way. If there were only one biotechnical engineer in 2010, and authorities told us that we needed a total of two biotechnical engineers in 2020, our chart would show that we needed a 100 percent increase in biotechnical engineers. While the 100 percent would seem very dramatic on a chart, compared to the growth in other fields, surely we wouldn't tweak our entire educational system to gain one more engineer over a ten year period. So it's important for us to know just how large this field is.

Obviously, this chart doesn't give us the information that we need.

2. Discover How Many Biotech Engineers We Actually Need

At this point, I began searching for the information I lacked. On a United States Department of Labor site I discovered that "because it [biotech] is a small occupation, the fast growth will result in only about 5,200 new jobs over the 10-year period."4

Thus, America as a nation needs to graduate 520 biomedical majors per year, during the ten year time period, to meet the demand for 5,200 new jobs.

3. Discover if Our Current Masters and PhD students Are Likely to Supply the Demand

America has over 550 graduate school programs related to biotech. Thus, if each of them graduates only one student per year, this could supply the demand. This isn't even considering all the undergraduate programs that offer biotech degrees. Nor is it considering the foreign techies that we grant temporary work visas to when we have a sudden or overwhelming demand in a field. Neither is it considering that almost half of those employed in STEM vocations don't even have or need STEM degrees. (The field needs a variety of specialists from various fields, not just biotech majors.)5

So where's the impending shortfall—the "comparatively few American students" pursuing "expertise in the fields of science, technology, engineering and mathematics?"

4. What Percentage of Students Do We Need to Push to Pursue Biomed Careers?

Over 15 million students are currently studying in America's four-year colleges, who will graduate with either undergraduate or graduate degrees (I subtracted the students who likely won't graduate.)6 Thus, the 5,200 total (not per year, but for the decade) biomed specialists we need is merely .03 percent of the current student population. In other words, we desperately
need, not three out of 100 students, not three out of 1,000 students, but three out of every 10,000 college students to major in biomed or a related field.

But let's give ourselves a bit of a cushion, since some may change majors or get a job in a different field. So let's say we need 10 out of every 10,000 (or 1 out of 1,000) college students to study for a biomed career. Surely, if we need so few students, we could offer incentives such as scholarships if we're falling behind.

So how many students does my local high school need to motivate into biomed?

The local high school my children attended has about 2,000 students. Assuming that they all graduate, how many students do we need to motivate to go into biotech to meet the need? If we need one out of 1000 students, that comes to about…two.

Actually, not all high school students go to college and some, once they get there, drop out, so let's be generous and say we need eight, which would be less than one graduate per graduating class over a ten year period.

So we're changing our curriculum and deemphasizing other career paths in order to get one graduate from each high school class to choose biomed? Do we really need to motivate more students to go into a field that seems to already have an overabundance of qualified workers? This is beginning to sound very odd.

But perhaps we're being unfair. We've obsessed on biomed students, without taking into account other STEM fields.

5. Ask, "Beyond Biomed, How Many STEM Workers Do We Need?"

According to the Department for Professional Employees, "In 2011, STEM jobs made up 5.2 percent of the total workforce nationwide." Compare this with the above chart and accompanying information. A part of the "crisis" they identified was that only 16 percent of high school grads were interested in a STEM career. Yet, if we already have 16 percent of our students (according to the above chart) heading for five percent of the jobs, why are we desperately pushing for more? Perhaps we should be redirecting some of them to other careers.

Again, according to this department, "The supply of new STEM graduates is robust." Just how robust?

In academic year 2011-12, 141,000 bachelor’s degrees were conferred to graduates in natural sciences and mathematics and 146,000 bachelor’s degrees were awarded to students in computer sciences and engineering. Also in academic year 2011-12, 26,000 master’s degrees were awarded in natural sciences and mathematics and 66,000 degrees were awarded in computer sciences and engineering. Nearly 25,000 doctor’s degrees were awarded to students in natural sciences, mathematics, computer sciences, and engineering in academic year 2011-12.

That sounds like a lot, but is it enough to meet the current needs?
6. Study the Current Job Market for STEM Careers.\textsuperscript{9}

The projected growth in the chart was for the years 2010 to 2020, which means we're well into this decade. Surely, if there's a crisis, we should see lots of unfilled job openings and extremely low unemployment in the field. So I Googled "finding a job in biomed" and "finding a job in STEM."

Here's what I found:

- A 2012 Washington Times article claimed that, while we keep pushing for more scientists, "the jobs aren't there."\textsuperscript{10}

- Only 14 percent of PhDs in biology and life sciences are finding positions to teach and research through our colleges within five years. "The supply of scientists has grown far faster than the number of academic positions."\textsuperscript{11}

- The pharmaceutical industry, one of the largest employers of STEM graduates, has downsized. "Largely because of drug industry cuts, the unemployment rate among chemists now stands at its highest mark in 40 years."\textsuperscript{12}

- A panel at the National Institutes of Health, another big employer of STEM grads, noted that a "glut of trainees and a dearth of academic positions in the United States is creating a dysfunctional biomedical research system, particularly biomedical students...."\textsuperscript{13}

- According to Jim Austin, at ScienceCareers, "...it seems awfully hard for people to find a job. Anyone who goes into science expecting employers to clamor for their services will be deeply disappointed."\textsuperscript{14}

- A 2011 study from Georgetown University found that "10 years after receiving a STEM degree, 58 percent of STEM graduates had left the field."\textsuperscript{15}

How Accurately Are We Able to Forecast Future Job Needs?

A 2012 National Science Foundation report, before giving their predictions of the growth in STEM jobs, admits that "Projections of employment growth are plagued by uncertain assumptions and are notoriously difficult to make."\textsuperscript{16}

They list such unknowns as how much the government and corporations will spend on research and development, how much research will be outsourced overseas, and the difficulty of predicting new products and industries that may emerge. Also, we can't predict economic crises, either domestic or global, that impact hiring.

Thus, the NSF report concludes, "The reader is cautioned that the assumptions underlying projections such as those that follow, which rely on past empirical relationships, may no longer be
valid."17

By contrast to the chart at the top of this chapter, a 2014 report of the National Science Foundation predicts that the biological sciences will grow 20 percent for the years 2010-2020. That's still a hefty increase, but less than a third of the earlier prediction of 62 percent.18

Since we’re well into the decade, surely it’s relevant to look at the present state of this much-anticipated surge of growth. According to the Bureau of Labor Statistics, here’s the state of STEM occupations through 2013.19

Well, that’s rather disappointing. If these figures can be trusted, from the years 2010 to 2013 computer and math occupations have grown (as a percentage of all professional occupations) by about one percent, architecture and engineering less than one percent, and the life, physical, and social sciences have decreased by less than a percent. (In fact, during the entire period from 2003 to 2013, the percentage of people working in the "life, physical, and social sciences" has decreased.) In the first third of the 2010 to 2020 decade, although we’ve graduated an abundance of STEM majors, we’ve yet to see signs of the huge projected increase of jobs.

How could economists have been so far off? Perhaps the boom will come in the last half of the decade. Yet technology, like other industries, doesn’t just keep growing forever. Instead, it goes through times of boom and bust. "There will be times when employers find it difficult to find technology workers, and times when technology workers are laid off en masse." And like other booms and busts in the economy, they’re terribly difficult to predict.20
Should You Go into Biotech?

If you're studying biotech, you may be panicking about now. Don't. If you think I'm telling people to leave the field, you've missed my point. The point is, we can't put our full confidence in government statistics and projections. We must think them through for ourselves.

If you're passionate about biotech, don't just study biotech; study the biotech *industry* to see where the jobs are and to understand the current opportunities and challenges.

By the time you read this, my stats will have grown cold and we may be experiencing a boom in biotech. Check the latest stats. Talk to people in the industry. Some suggest that getting a more general engineering degree would allow more nimbleness to pursue the growth industries in science after you graduate, and to change careers if those areas later fade. Read articles in the industry. Also read the comments of real, live engineers, scientists and mathematicians who comment below the articles, sharing their real life experiences.

Tips from this study:

1) Always look closely at statistics and charts, whether they're coming from respected experts, Harvard University, or huge government surveys. Understand exactly what they're purporting to show.

2) Consider the potential for bias in presentations. Would the organizations supplying or presenting the information be more likely to receive government grants if the statistics were dramatic?

3) Ask good questions, such as,
   - How were these statistics gathered?
   - Are there alternate ways to interpret them?
   - Could they be charted (displayed) a different way to give a different impression?

4) Find other relevant data that might either confirm or call into question the original stats.

Conclusion

Why do brilliant people believe nonsense? Because they base their beliefs on faulty or misleading statistics. So pay attention to statistics and their accompanying charts. Challenge their assumptions. Question their conclusions. Consider the agendas they may represent.

And NEVER STOP THINKING!
Think Different!

Using Google with More Finesse

My research for this chapter was done largely through using Google, not the specialized databases available only through universities and libraries. Learning to use Google effectively can pay rich dividends as we think our way through life and try to see through nonsense. Here are a few tips to using Google more effectively.

1. Start by asking the right questions.

When I first looked at the statistic on the growth of STEM occupations, I realized that the stats weren't giving me the information I needed. They only gave me the percentage increase. These are some of the questions that first came to mind:

- Where did this stat come from? A respected organization? It didn't tell.
- What is the evidence that we'll have a huge lack of workers?
- Do other estimates of percentage increase differ?
- How many people are currently working in STEM jobs?
- If this is indeed a growth industry, how many slots do we need to fill?
- How many people are currently being trained for these slots?
- What are other ways these slots can be filled? (International work visas, people trained in other areas, one year certificates, two year degrees, etc.)
- Are we currently seeing a dearth of workers in these areas?
- Are there reasons for bias that might impact the formulation and presentation of these statistics?

2. Search Google with key terms.

Keep trying different combinations of words until you find the data you need, for example: "STEM jobs," "Percentage of STEM jobs," "Statistics on STEM jobs," "Careers in STEM jobs," etc.

3. Keep organized!

For this study, as I gathered large amounts of data, I copied and pasted information into a Microsoft Word document under headings for each of the questions/sections.
4. **With each article or resource you read, note the terms and references that are just begging to be followed.**

Think like Sherlock Holmes; you're gathering clues for further research as you're going along. One article may reference a study that becomes the key to unlock the rest of your research. If it looks promising, highlight it and mark it for future snooping.

5. **Learn to search within articles and books.**

So you find an online book that you've been told contains a study on the growth of STEM occupations. The table of contents doesn't help. At that point, search the document by clicking Ctrl/F on your keyboard (or whatever your operating system uses to search a document) and typing STEM into the box to find all references. To search within a pdf, use the search provided by Adobe.

6. **Learn how to narrow your searches.**

For example, if you want to search for government statistics on STEM related subjects, type "STEM .gov" into Google, which prioritizes information about STEM on government sites.
Flex Your Neurons!
Pursuing the Point of Know Return

1. Try to find solid information on career prospects that might match your strengths and interests. Search terms/phrases such as “careers” and “best jobs” and “average pay for jobs” to try to find the best (most accurate, up-to-date, thorough and useful) career sites. Bring your results back to class for discussion.

2. What harm might come when we unnecessarily prioritize spending and weight curricula toward pushing huge numbers of students toward a narrow set of occupations? For example, many predict a coming shortage of physicians. Since physicians aren’t typically counted as STEM workers, might we contribute to a shortage of physicians by not financing and emphasizing them as much as STEM professions?

3. A doctor recommended that my dad start taking a blood thinner, which would cut his possibility of having a stroke in half. What questions would you like to ask the doctor before making this decision? (Think particularly about what we just learned about "percentage increase" and apply it to "percentage decrease." Teachers can look to the online teacher resources to find my answer.)

4. When a politician says that during his term he “lowered the national deficit,” does he mean that he lowered the national debt, or that he merely reduced the amount that the debt was increasing (percentage decrease)?

5. Collect some statistics that you see in various advertisements. What questions would you like to ask to determine if the stats truly prove what they claim to prove? (Example: 100 percent of dentists surveyed prefer ____ toothpaste. But how many dentists were surveyed? How were the dentists chosen? Do other surveys of dentists show the same preference?)
Making It More Personal
Practical Takeaways

What are one or more ideas provoked by this chapter that you can apply to help you think more critically?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

What are one or more ideas that you can apply to help you think more creatively?
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____________________________________________________________________________
____________________________________________________________________________

What else do you want to make sure you don't forget?
____________________________________________________________________________
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____________________________________________________________________________
Recommended Trails
For the Incurably Curious and Adventurous

1. To do further assessment of the future of STEM jobs, read some of the articles that I referenced in the endnotes for this chapter.

2. If you’re pursuing STEM vocations (or any specific vocational area), find the most authoritative sources to track the types of jobs available, unemployment stats for various sectors, who’s hiring and where, etc. If a Google search fails to uncover the best sources, ask your librarians…they live for moments like this!

3. Seek out people in your field of interest to ask about job prospects (what people actually do during an average work day, where jobs are available, is it fun and fulfilling?) Job fairs often put you in contact with such people. Also, look for specialized online communities.

4. To learn more about tricks and tips to use Google more effectively, see the appendix on this topic in the accompanying website:

CHAPTER 17
THEY MAKE COMMON STATISTICAL BLUNDERS

"Eighty percent of statistics are made up on the spot."
— Anonymous

Everybody's Having Sex!

Most teens are strongly driven by peer pressure. If they believe that their friends are all taking drugs, they're more likely to take drugs. If they believe all their classmates are having sex, they feel strong pressure to not miss out.

That's why it's important for us to know how many young people are actually having sex. If your 15-year-old sister feels that she's the only virgin left in her age-group, she's more vulnerable to yield to the pressure of her 18-year-old boyfriend. "After all," insists her boyfriend, "everybody's doing it. Don't be a prude."

Unfortunately, the media and educators and government agencies often increase that pressure by relying on and quoting misleading statistics, apparently to call attention to issues they feel need to be addressed.

Ever since the 1960s we've been strongly influenced by the sexual revolution. Everyone except recluses living in caves seem to know that everybody's having sex with everybody, unless there's something wrong with you. Thus, in an episode of the popular TV series House, the awe-inspiring diagnostician, in considering a sexually transmitted disease as a possible cause of the troubling symptoms of a young boy, says something to the effect of, "We all know that 110 percent of all 16-year-old boys are having sex."

So imagine that you're a 16-year-old virgin watching this episode. You feel humiliated, out-of-touch, unpopular. The next day at school your respected health teacher begins a section on sex ed. "I'm not so out of touch as to imagine that you're not having sex. I just want to teach you have to have it more safely." Once again, you feel the flush of embarrassment at being a virgin when everybody else has already experienced sex.

In assuming that "everyone's doing it," aren't teachers encouraging—even prodding—peer-driven teens to start sex early? I recall a substitute teacher who addressed a sex education class of 15-year-old girls and suggested that they should put off sex till they find someone they
want to spend the rest of their lives with. Girls came up after class and said, with huge expressions of relief, "You mean it's okay to say no to sex?" Apparently, their regular teacher had, either implicitly or explicitly, communicated that 15-year-old sex was expected and inevitable, thus putting strong pressure on her students to join the crowd.

**Think!**

What percentage of 15-year-old girls do you estimate are regularly having sex? How many do you think have had sex only once? How many not at all?

**So What Do the Stats Really Say?**

I researched this issue in some depth in the late 1980s and early 1990s while I assisted a public school system with their sex education program. The media, health authorities, government agencies, and popular music converged to tell us that most young people were having sex. But in order to think through our approach to teaching sex education, I needed to start with accurate statistics. After all, one survey found that the greatest pressure to have early sex is neither love nor lust, but peer pressure. And with millions of teens acquiring sexually transmitted diseases each year, along with increased emotional anguish and the risk of pregnancy, the stakes were indeed high.

"Everybody's doing it" was based upon a statistic claiming that most teens are "sexually active." Thus, the regular teacher of the 15-year-old girls' health class likely started with this assumption and expressed it to her class as "I know most of you are having sex...." But this statement makes several assumptions, making it a good example of how statistics can lead us astray.

1. **Older teens are more likely to have had sex than younger teens.**

   Since most 18 to 19-year-olds are out of high school, graduates shouldn't be included in statistics that claim to assess high school students. Some older teens are even married. When we limit our study to only high school students, I found that most high school students had not experienced sexual intercourse, not even once.

   But the health teacher was speaking to a specific subset of high school students—15-year-old girls. The most comprehensive surveys found that 70 percent of them had never had sex. And if you subtract from that 70 percent those whose only sexual experience was involuntary (rape), then 80 percent of that age group had never had voluntary sex.

   It's beginning to look like, among 15-year-old girls, the great majority are *not* doing it.

2. **The term "sexually active" is misleading, seemingly designed more to arrest public attention and heighten the sense of urgency than to paint an accurate picture of high school sex.**
Remarkably, to the researchers and agencies feeding the information to the public and our schools, "sexually active" meant "have had sex at least once." Yet it was seldom defined in popular media and gave the impression that every youth who was "sexually active" was "sleeping around" or "having sex most every weekend."

Yet, surely we wouldn't consider a person "physically active" if he had walked around the block once in his lifetime. We'd expect him to be getting regular exercise, at the very least once a week. It certainly confuses the issue to label someone "sexually active" when her sole sexual experience was a rape at the age of 14, or one voluntary act of sex that she later regretted.

(As an example of how confusing this phrase can be, when one girl was asked if she was sexually active, she responded, "No, I just kind of lie there.")

As a result of these confusing statistics, agencies and educators and journalists gave the impression that most high school students were sleeping around. So how many are actually "active" in the sense of either having sex regularly or sleeping around? One study found that 20 percent of the teens categorized as "sexually active" had experienced sex only once. Another study found that only 14 percent of high school girls had accumulated four or more sexual partners.

In fact, one survey found 84 percent of teen girls saying that what they most wanted to know about sex was how to say no without hurting the other person's feelings.

So much for "all high school students are sleeping around." So why are so many high school students feeling such pressure to start having regular, early sex? Why do they think everybody's doing it? Sure, Hollywood must take part of the blame, but sensational news reporting, sensational reports by respected agencies, and naïve educators should shoulder part of the blame as well.

Why do brilliant people believe nonsense? Because they fail to look deeply enough into the statistics that impact their decisions and their teaching.

I hope that this look at the statistics of sex and how people use them gets you a bit angry. After all, we're talking about people here: our little brothers and sisters, our friends. When we allow people to pass on misinformation, we hurt people.

My point? Statistics are important. Interpreting them incorrectly impacts not only us, but the people we love.

**Frequent Statistical Blunders**

Familiarize yourself with the most common statistical fallacies and you'll be more likely to spot them in your reading and viewing.
Look Carefully at How Charts Display Data

Failure to Maintain Consistency

In 1976, a respected science foundation posted a graph purporting to show an astonishing drop in the number of Nobel Prizes in science that were awarded to U.S. citizens.\(^6\)

Think!

Look carefully at the chart below before reading my explanation. Can you see what's potentially misleading?

The problem? Each period of years represents a decade, *except for the last one*, which is for only four years. No wonder we see a huge drop in Nobel Prizes! We would expect the period of four years to show less than half of the winners for the typical ten year period. That's exactly what we find. But graphing it in this way gives the strong (but wrong) impression that we've lost our scientific edge.

So let's take a longer view, showing the rest of the decade after the chart was published.
Now that's more like it! America's back in the Nobel Prize ball game! Whatever their reasons to publish such nonsense, it well demonstrates how charts can be manipulated to conform to someone's agenda.

The moral of the story? Always make sure that charts maintain consistency in the spaces allotted for periods of time or any numbers.

**Omitting Origins**

Some of you would like to teach—perhaps in a school or seminars or a service organization or a summer camp. All communicators should be interested in the claims we're about to assess.

Imagine that you want to hone your teaching skills, so you look up some articles on teaching and find this vital information, presented on the website of one of our most respected institutions of higher learning.⁹

"Research on student attention in lectures has demonstrated that attention levels naturally vary during lectures in predictable ways. In fact, attention is high during the first minutes, then it falls down and stays flat for the rest of the lecture. Toward the end of the lecture, attention picks up again, with some fluctuation, according to the following graph. (Bligh 2000)":
At first glance, it tells me that students listen attentively for the first couple of minutes, then they quickly fall into a near comatose state, remaining there till the last few minutes of the lecture, where they regain just enough consciousness to close their notebooks in preparation for their next classes.

My takeaway? If I want to say anything important, I'd better say it in the first couple of minutes, since the rest of my lecture is pretty much a waste of time.

Although I find this graph in many authoritative articles and presentations, the more I thought about it, the more I smelled a rat.

Think More Deeply!

What's lacking from this chart? Does the chart jive with your personal experience and your observations of fellow students during lectures, even if they're interesting?

Here's how I dug a bit deeper and what I discovered.

1. I first noticed the lack of numbers and labels on the x and y axes.

Without numbers, the chart is almost meaningless. Note two ways the chart could be presented, depending on the numbers that informed the chart and their meaning.
Presentation One - The most natural way to read this graph is to assume it's measuring students' attention, with zero attention (comatose) at the bottom and maximum attention (students fully dosed on Ritalin/Adderall) at the top. From left to right, we'd see the timeline of a typical one hour lecture. (See chart with my wording below.) Is that how you interpreted the original chart?

Presentation Two - An alternate way to look at this data would be to assume that the above graphic omitted the origins (doesn't begin with zero attention), making the drop in attention appear much more dramatic. If so, then by reinstating the origins, we would see the wane of student attention in a much less dramatic light. Note how wildly different this looks (see chart below), compared to the graph that started with zero!

So which of these two (or something between these extremes), represents the truth behind the chart? Without further snooping, we have no way of knowing, since nobody's giving us any numbers to graph.
2. My second suspicion arose when I activated my higher level thinking enough to compare it to my own experience.

"How does my own attention fluctuate when I attend a lecture?" I asked myself. Of course, my attention varies significantly according to the content of the lecture (relevant versus useless) and the quality of the speaker (riveting versus a hopeless bore). Yet I don't see anything in the chart allowing for such extremes of relevance and quality.

In general, I do admit that I'm probably a bit more alert at the start of a one hour lecture than 40 minutes into it. Yet, I'm still paying at least enough attention to continue taking notes. I'm not comatose. If she's a decent communicator on a tolerable subject, and 30 minutes into the lecture she shares an entertaining illustration or a piece of new information that is especially relevant, I'm all ears. If 40 minutes into the lecture she tells a hilarious life experience or joke, I often laugh and look around to find the rest of the audience laughing as well. They certainly don't seem comatose.

3. My suspicions were confirmed when I dug up the source.

The above university webpage cited the source of the chart as "Bligh, 2000," in a book titled What's the Use of Lectures? I pulled up a free digital version of the book through my university library and found the original chart, which I discovered had somehow evolved significantly over time. [See below. Note the much milder downward curve and how the last jolt of attention comes much closer to the original level of attention/performance (see below) than in the more recent drawing of the graph (see above)].

![Chart](image)

Same Study as Presented by Bligh in the Year 2000 in His Text

One difference I notice is that this chart says it's measuring "Level of Performance" instead of "attention." In the accompanying text, Bligh explains that Lloyd had observed the frequency of students taking notes, assuming that more note taking correlated with more learning. So in reality the chart merely tells us at what points in the lecture his students took the most notes. From that bit of data he hypothesized that taking more notes indicates better attention and leads to better performance.

But wouldn't an equally viable hypothesis be that almost all students take notes during the opening of the lecture to write down the title of the lecture and briefly explain the topic of the
day? As the lecture proceeds, students probably write much less—only the points they think will be relevant to the test. At the end of the lecture, if the teacher summarizes his main points, wise students jot down those main points, since they may be on the midterm. Thus, if this hypothesis proves consistent with note-taking behavior, the study found precisely what we'd expect, even if it had no correlation whatsoever to attention or performance. In other words, this study may say little to nothing about waning attention during lectures. 9

Bligh notes the inadequacies of Lloyd's study and after comparing other studies concludes, not that all lectures are largely ineffective after the first five minutes, but that "...the first 20-30 minutes of a lecture are different from the remainder. The remainder is probably less effective and less efficient." 10 This is a vastly different impression than I got from viewing that original chart.

Although Bligh's description of Lloyd's study helped me to understand what the study was about (note taking), it didn't help me to put numbers on the graph, in order to see just how dramatic the dip in note taking was. For this I had to order Lloyd's original study through interlibrary loan.

Here is Lloyd's original chart:

My first observation is that each of the "copies" of this chart, as used by later studies, was redrawn, and not to the original scale. I sincerely hope people weren't skewing the chart in order to make their points more dramatic. Let's assume the best: perhaps scholars were working from a faded original and a limited budget, so they gave it to a first grade child with crayons to redraw to scale for publication.

My second observation is the lack of numbers on the "Performance" axis. Reading the original "study" explains the omission. The author tells us that there was very little (if any) scientific study behind the chart:

"The conclusions which follow do not represent the results of an experiment or even
those of a formally organized enquiry. They are basically a synthesis of personal judgments arrived at, some subjectively, some more objectively, over the years."11

In brief, Lloyd observed his biology classes (less than riveting subject matter, I might guess) through the years, talked to his colleagues about their impressions of student performance during different points of the lecture, and finally took two of his biology lectures and looked over the notes from 19 of his students. He found that they took more notes at the beginning of class, dropped off sharply after 10 minutes, then experienced a small upsurge in note taking late in the class. From this he assumed that their attention waned after the first 10 minutes. Since he didn't pretend to know how much their attention waned, he didn't put numbers on it. Perhaps this is why later scholars felt free to redraw the chart to suit their needs.

My third observation is that Lloyd drew his bottom line much farther up on the vertical axis, giving the impression that although he thought students’ attention declined after the first ten minutes, they didn't go anywhere near completely comatose. (More precisely, concerning what he was measuring, they didn't completely stop taking notes during the middle of the lecture.)

4. I gained further confirmation of my suspicions by finding more recent studies relevant to attention spans.

Lloyd published his original "study" in 1968. What relevant research has emerged since then?

A more recent study actually tested how much students were retaining from each segment of a lecture. No differences in retention were found, indicating that attention must have remained at levels at least adequate to retain the content until the end of the lecture.12

In another study students used clickers to indicate when they had a lapse in attention. Throughout the class time, with the first spike being at about 30 seconds into the lecture, students reported lapses (mind wandering) of mostly a minute or less. The numbers of lapses increased over the course of the lecture, but attention was much better when teachers interspersed active learning.13

What We Learn from these Studies

Lectures aren't futile, as the original chart seemed to indicate. Instead,

"...a good lecture, one that is well crafted and expertly delivered, can surpass instructional media not only in cultivating so-called higher levels of learning, such as critical thinking, analysis and problem-solving skills, but also in the transmission of factual information" (Figlio, Ruish & Lin, 2010).14

But students do indeed get distracted, and more so as the lecture goes on. So in addition to learning to lecture well, in many contexts teachers would do well to avoid speaking nonstop for more than 15 to 20 minutes at a time. Instead, they would be wise to break up lectures with active learning such as student discussions to maximize student learning.15
Thus, regarding statistics, we see how the original chart didn't provide a clear origin, and subsequent drawings cut the origins even more, giving the impression that attention decline was far more drastic.

**How Those with Agendas Can Manipulate Statistical Charts**

Omitting origins allows people to take relatively minor differences and make them look huge.

(Isn't this fun? We're learning to think like many political statisticians!)

So let's look at one more example of omitting origins to demonstrate how agendas can influence presentations of statistics. Imagine that you're a politician and a major part of your platform is to improve education. You're preparing a PowerPoint presentation and have asked your statistician to prepare a chart showing how America compares to other countries in test scores. Follow the conversation:

**Statistician:** I've got stats on science testing for 34 primarily prosperous, first world countries. Since test scores are heavily influenced by poverty rates, I figured that the rest of the world (about 162 other countries) would typically score worse than us, which puts us in the top 10 percent. According to this chart, we're looking pretty good!

**Politician:** Well, I think you're having to guess too much. Surely many more of those countries are out-educating us. Besides, this chart makes us look too good. Let's cut out the rest of the
world and just compare ourselves to some of the first world countries.

**Statistician:** Okay. So the PISA test was given to 34 OECD countries, which are almost all developed, first world countries. We were close to average, which might not be so bad when you consider America's demographics, including large pockets of poverty and large numbers of students who are still learning English, which is extremely different from so many of the largely homogeneous cultures that beat us on testing.

![Comparing 31 OECD Countries](chart)

**Politician:** That won't do at all! The chart suggests that there's not that much difference between us and other developed countries. With bars that long, it looks like the difference between our scores and those above us might be the difference of just a few questions on the test. Can't you make it look like we're further behind the top countries? For goodness' sake, a big part of my platform is education. I need to convince people that we've got a crisis on our hands!

**Statistician:** Right...now I get it! You want me to "torture the data until it confesses what you want it to say." So let's hide all those lower numbers on the bottom of the chart and focus on the higher ones by eliminating the origins, so that the difference looks more dramatic. How about this?
Politician: Much improved! But those countries that lag behind us still make us look better in comparison to them. Can't we do something about that? When I give my presentation, I need people to gasp, to moan, to feel like we're in a desperate mess.

Statistician: I think I'm catching on…how about this?
Politician: That's it! But is it accurate? What will the fact checkers say?

Statistician: Oh, it's completely accurate. Since we knew that the USA came in about average among the developed countries tested, and that we were ranked at #20, we just lopped off the rest of the bunch and compared solely the top 20. That puts us dead last!"17

Tip: To critique statistics, it's often helpful to put yourself in the shoes of the people presenting the statistics. Ask, "Might they have reasons to present data in a way that fits their personal agendas?" Sadly, the final graph is closer to the way we typically see these stats presented, since presenters often want to use the data to shock their audiences and move them to action.

Erroneous Extrapolation

In 1940, each car on a highway carried an average of 3.2 people. Fast forward to 1960 and the average was 1.4. This was a drop of 1.8 people in two decades. Extrapolate this out and by 1980 we should have had an average of less than 0 people per car! Of course, this is absurd. Yet it demonstrates the folly of assuming that past trends will continue indefinitely into the future.18
Especially beware of extrapolations concerning investments and the economy. Financial advisors often show charts of past performances to encourage us to invest in a certain stock or mutual fund or industry.

Imagine that you want to invest $10,000 so that it can grow into a substantial down payment for a house. It's January of the year 2000. Tech stocks (as represented by the NASDAQ stock exchange) have been growing rapidly and the NASDAQ is close to reaching 5000.

Your financial advisor shows you the graph below, extrapolating that tech stocks can only keep going upward. "After all, this is 'the new economy,'" proclaims your advisor, "based on the explosive growth of technology and particularly the Web. Had you invested your $10,000 four years ago, you'd have almost $50,000 by now. The Web and technology are our future—they aren't going away. They can only keep going up!"
He seemed like a nice enough guy, and he was always reading up on technology and investing, so you put your $10,000 into a fund that indexes (seeks to mimic) the tech-heavy NASDAQ. The following chart shows what happened to your money over the following eight years.
In simple terms, a few months after you invested, the bottom dropped out of tech stocks. It was a bubble. (Economic bubbles are so obvious after they burst.) The extrapolation into the future looked nothing like what actually happened. Eight years after buying in, your $10,000 worth of tech stocks are worth about $5,000. You’d have likely done better buying a $10,000 bass boat. At least you could have brought home something for supper.

So much for "the new economy."

Our tendency to use past stock market data to extrapolate into the future is so pronounced, and so often wrong, that reputable investment companies post a warning beneath all of their reports of returns:

"Past performance is no guarantee of future results."

It's just another way of saying:

"People often get into trouble when they extrapolate charts into the future. It's risky
behavior that has lost many a fortune."

Cherry Picking

This was another deceptive factor in the above investment advice. The advisor failed to show us a long-term chart of the behavior of tech stocks, which would have shown times of growth and decline, bubble and bust. By cherry picking only the most current period of growth, I had no way to consider the bigger picture.

Presenters are notorious for choosing a period of time that supports their position.

Failure to Understand Primary Sources
And How the Data Was Derived

To evaluate the claims about student attention, I dug up the primary sources. It's truly amazing how many authorities keep quoting statistics and passing along charts without ever checking the data they're based upon.

Concerning evaluations of education in America, it's often reported that our test scores have been plummeting through the years. Bob Wise, president of the Alliance for Excellent Education and former governor of West Virginia, referred to our education being in a "free-fall." According to an article in Newsweek, "U.S. students, who once led the world, currently rank 21st in the world in science and 25th in math."

So just when were these golden years in American education when we "led the world?" I can't find them. According to Brookings Institution scholar Tom Loveless, a noted expert on international testing, we never led the world in scoring. According to him, the first test comparing us to other countries was performed in 1964. Our 13-year-olds came in next to last compared to the other 11 countries tested.

According to Loveless,

"The United States never led the world. It was never number one and has never been close to number one on international math tests. Or on science tests, for that matter. It is more accurate to say that the United States has always trailed the world on math tests."

So who do we believe, Wise or Loveless? If this issue is important to you, dig into the data for yourself. If writers/speakers fail to document their sources, they may be repeating nonsense, no matter how great their credentials are.

Poor Arguments from Accurate Data

I love following the Atlanta Falcons, learning a bit more each season about the intricacies of professional football. A few years ago, when running back Michael Turner was having an outstanding season, I read the following comment by a fan or sports analyst: "Whenever the
Falcons run Michael Turner enough to churn out over 200 yards, the Falcons win. So, it's obvious what we need to do going forward. Run Michael Turner!

To put this into a syllogism:

**Premise 1:** "If Michael Turner ran over 200 yards per game in every winning game so far, then coaches should always prioritize running Turner."

**Premise 2:** "Turner ran for over 200 yards per winning game so far this season."

**Therefore:** "Prioritize running Turner."

**Think!**

Budding football analysts, what problems do you see with this argument?

My problems are with the first premise.

- What if the coaches prioritize running Turner only in games where the opponents don't excel at stopping the run?
- What if the next team we play stinks at defending the pass, but excels at stopping the run? Shouldn't we prioritize our passing game instead of running Michael Turner?
- What if the two offensive linemen who open up holes in the defensive line for Turner are currently on injured reserve?
- What if, since the next team we face is also looking at these statistics, they double team Turner?

If any of these four scenarios bear out, we'd be wise to *not* run Turner full out every game.

Football, to the casual observer, consists of a bunch of burly fellows trying to get a ball across a line. To the sophisticated analyst, it's an extremely complicated game of chess, where no two pieces (players) are exactly alike, the pieces constantly change (injuries and substitutions) and strategies often change midgame to exploit a perceived weakness or to counter the opponent's strategy.

Thus, to truly understand how a statistic may apply to running an NFL team, we need to understand more than logic. We need to understand football.

**Conclusion**

H.G. Wells wrote long ago, "Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write." That day has arrived! Every day, the media delivers
statistics concerning sports, investments, education, health, the job market, and business. Those who don't know how to evaluate statistics are at the mercy of those who spin them to support their agendas.
Flex Your Neurons!
Pursuing the Point of Know Return

1. Are fatty diets really a major health risk? One recent researcher claims that the original researchers cherry-picked the countries studied, purposely choosing countries that fit their hypothesis. Read the article and see if you agree. Nina Teicholz, "The Questionable Link Between Saturated Fat and Heart Disease," Wall Street Journal, April 22, 2015; http://online.wsj.com/news/article_email/SB10001424052702303678404579533760760481486-IMyQjAxMTA0MDEwMzExNDMyWj

2. How much water should we drink each day for optimum health? Is the evidence for eight cups a day sufficient? Here's an article to begin your search: http://www.blogofherbs.com/advice/squashing-the-8-cups-of-water-a-day-myth

3. During the "Cold War" between the Western World and the Soviet Union, I heard of a one-on-one athletic event between a Russian and an American, with the American winning. The Russian press release read, "Russia Places Second, America Next to Last." Perhaps it was only a joke, but it well demonstrates how titles can skew data. This week, look for illustrations of how titles of articles show bias in reporting studies.

4. Freshmen in college often perceive that "everybody's drinking" alcohol, putting pressure on them to "grow up" and join the crowd. One study found college students estimating that only five percent of their fellow students are not drinking. But are their estimates highly inflated? Try to find some well-done, recent statistics on how many college freshmen are actually drinking on a regular basis. Bring your results to class for discussion.
Making It More Personal
Practical Takeaways

What are one or more ideas provoked by this chapter that you can apply to help you think more critically?

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

What are one or more ideas that you can apply to help you think more creatively?

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

What else do you want to make sure you don't forget?

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__________________________________________________________________________
__________________________________________________________________________
Recommended Trails
For the Incurably Curious and Adventurous

For a good introductory text on statistics, especially for those who are scared of math and statistics, I like Gary Smith's *Introduction to Statistical Reasoning* (New York: WCB/McGraw-Hill, 1998. Older editions are more affordable). It uses lots of practical, clear, interesting, real-life examples. It also concentrates on critical thinking and problem-solving skills rather than memorization and plugging in formulas. Like the present book, Smith chose to begin chapters with interesting dilemmas rather than begin with a formula followed by examples—a great way to engage interest and higher level thinking.