Essays & Commentaries I

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Citation inflation and its remedies

The recent announcement from the ATLAS and CMS particle physics experiments at CERN that they might be seeing a signal of a 750 GeV resonance (i.e., new particle) decaying into two photons is very exciting. Much is being written on this potential signal for new physics. However, there is another phenomenon that is not new but is equally visible in the wake of this development. That phenomenon is citation inflation.

Citation inflation is when authors write a paper and reference many more papers than need be referenced, and often well beyond those they have even read or looked at. In the old days a reference to a paper was listed because the author(s) directly used a result for their present study, or the reference was acknowledged to be first to recognize some specific finding in the research field. Today references are added in the dozens in nonspecific contexts. For example, you may read in a paper a sentence like this: "Other studies [1-78] have addressed the possible interpretations of anomalous g-2." And then in the references section of the paper there are 78 papers listed, numbered 1 through 78.

When Einstein wrote his theory of Brownian motion article he cited only two authors, himself and Lectures on Mechanics by Kirchhoff. Today, reference lists in papers much shorter than Einstein's can extend into the hundreds of publications.

Origin of citation inflation

What is the reason for this inflation of citations? For one, science has progressed. We have many more theoretical physicists in the world than when Einstein was working, and many more publications. Perhaps the ratio of citations in individual papers today to those of Einstein's time is consistent with the ratio of total number of papers today vs. then. However, even if this were so, it is unambiguous that the referencing today includes carpet bombing of marginally relevant papers compared to the referencing of yore.

A second and more insidious reason for this dramatic increase in referencing is that it is completely free to reference as many papers as you like. There is no down side to reference an even marginally relevant paper, but potential downsides if you do not — you may get an angry email asking why you are not citing their paper(s) even if they are only tertiarily relevant to your study. There is no reason to deny such giving in to such demands since there is no penalty today for citing an almost arbitrary number of papers.

Perhaps we as a community do not wish to rectify this problem. Citation inflation is occurring, yes, but with online articles it arguably does not matter that it takes up a lot more space at the end of an article, and maybe readers want to see all the papers that are even remotely relevant to the subject.

However, there are at least two reasons why we may wish to bring this citation inflation under control. One, it becomes harder to evaluate the quality of papers upon entering a subject. In the limit that every paper is cited that is merely related to the subject at hand, citation rates for a paper further lose their correlation with quality. Second, it obfuscates the questions of prior art. The huge citation rates tend to obscure the people who first made significant observations.

What to do about it?

Perhaps these reasons are not strong enough to do something about citation inflation. However, if we do want to do something about it, we somehow have to introduce a penalty for over-citing. Two ideas come to mind. The first approach impacts one's career metrics. The count for citations in your paper could be normalized to the number of references you have in the paper. For example, if you reference 50 people in your paper and your paper receives 100 citations, you get a "normalized citation metric" of 2 (100/50). Likewise if you reference 50 papers and your paper receives 10 citations you get a citation metric of 0.2 (10/50). This actually correlates quite well with the purposes of controlling citations and the identification of original papers. For example, very mature fields and review papers always have more papers that one really must reference. Yet, these are the most likely papers to not have much original thought in them. Therefore, the proposed "normalized citation metric" has additional value beyond stabilizing citation rates.

Another penalty that could be introduced is a "readability penalty". Somehow your paper should become unreadible if you write something like, "And others have worked on this [1-78]." How to accomplish this? One way is to change the style rules of the articles. An effective style rule against such over-citing is that all citations must have author and year in the text itself and then the reference page at the end is in alphabetical order to find the details of the reference. For example, in such a style you would have to write "And others have worked on this (Weinberg 1964; Glashow 1962; Jarlskog & Yndurain 1972; ….)." If you wanted to write out the citations for all 78 articles your paper would become totally unreadable. Authors are then forced to give up precious in-line reading space only to references that really deserve to be there. Some journals already have this style mandate, but it was formed well before the onset of citation inflation. Perhaps all journals should consider going to it.

(2016)

English dominance may be hurting science?

Globalization in the last few decades has only increased the power of English in international science communications. English accounted for less than two-thirds of all scientific publications in 1980 and now is over 95% [1]. The hold-outs are mainly regional journals that have no ambitions for a global audience.

Linguistic requirements on students have also changed. As a PhD student at the University of Michigan in the 1990's we had to be certified with some competency in a foreign language. German, French or Russian were the only three that would count. I certified in German. However, most of my fellow students couldn't be bothered with the language requirement and were passed off for knowing a computer "language" such as C and fortran. It was a slippery end-around to a rule becoming quickly irrelevant, and a few years later the foreign language rule was scrapped all together.

The rise of English

The language of written scientific communication up until about the early/mid 18th century was largely in Latin, but local languages were becoming increasingly represented. By the mid 18th century scientists scrapped Latin and wrote in a "living language" they felt most comfortable with. English, German, Italian, French and Russian were all well-represented in the western world. English began to push out all others most notably after World War II.

And now today, in my entire career I have never been to a conference that was not in English, nor do I know anybody writing a scientific publication for general consumption in anything other than English. These are brutal facts about the current state of linguistic diversity in the scientific world, but an interesting question is if we are losing out by this lack of linguistic diversity. Some say we are.

Supporting German

In Germany there is a group called ADAWIS (Arbeitskreis Deutsch als Wissenschaftssprache) that laments the fall of German in scientific discourse so much that they have made a quasi-union of German-speaking scientists. In their guidelines document [2] they make the lamentations clear but also claim that the rise of English at the exclusion of other languages "limits the scope of intellectual inquiry and hinders cultural understanding and the anchoring of academic research in society."

These points deserve reflection; however, I am skeptical of the second point. Although "cultural understanding" is great, and most of us are all for it, it is a comparatively weak argument that writing papers in German on Higgs boson decays or RNA transcription is critical for that. The other two points they make are more important in my view.

Knowledge is aided by linguistic diversity

How might the rise of English "limit intellectual inquiry". The group's main complaint is that "knowledge depends on linguistic diversity." For example, they say that "understanding is sharpened and deepened through a comparison of terms in different languages for similar things and concepts." This argument is reasonable to me. Bilingual beginning physics students of physics can compare, as one example of many, "angular momentum" in English to "Drehimpuls" (turning impulse) in German and gain a modicum of more understanding from the exercise.

I also know that reading the excellent "Statistique Physique" by Diu et al. [3], which is not available in English, was somehow additionally enlightening in ways that I was not able to articulate as well as ADAWIS does: "Since reality is structured and represented in a different way in each language, the co-existence and competition between as many academic languages as possible must serve to encourage the generation of new insights"[2].

Discouragement of talented non-English speakers

The third reason to support research in the local language, to "[anchor] academic research in society", is also reasonable to me. A society that speaks language A but requires everyone to communicate in language B, even for their own research funding applications, diminishes the identity and security of the country and their citizens. A country of 80 million such as Germany that at times does not allow its citizens to write exclusively in their own language in order to compete in a scientific discipline risks losing out on scientific talent that does not feel comfortable participating in that environment. Indeed, sometimes the greatest mathematicians and physicists are ones who struggle the most in language, and to add that extra required burden on them may weaken academic research in their native lands and globally.

Rejection of cultural arrogance

Despite seeing the large benefit in maintaining linguistic diversity, there is one claim I disagree with that is hinted at in different ways by fellow diversity advocates. I reject the claim that some languages are intrinsically better than others for scientific discourse, or any other discourse for that matter. It is cultural arrogance that is unlikely to be supportable in any significant way. Ralph Mocikat, the chair of ADAWIS, says, for example, "the augmentation [going from evidence to conclusions] is more linear in English-language papers, whereas the German grammar facilitates cross and back references" [1]. This is close to declaring German intrinsically better than English as a language, when the fact is that extremely articulate people in

English can do whatever extremely articulate people in German can do, and vice versa. The key is that they do it in their native tongues.

Costs of language diversity

In the limit that we all had an infinite amount of time, I'd highly recommend learning German or French or Russian and reading and writing science in those languages too. It is enlightening and beneficial. However, the big question remains of which costs are we willing to pay: the costs of striving to maintain linguistic diversity, or the costs associated with lack of linguistic diversity. The world has answered that question by giving up on linguistic diversity. Nevertheless, it is worth concerted effort to determine if we are all indeed losing out by the dramatic ascendancy of English.

References

[1] Pickles, M. (2016). "Does the rise of English mean losing knowledge?" http://www.bbc.com/news/business-35282235 (accessed January 18, 2016)

[2] "Arbetskreis Deutsch als Wissenschaftssprache: Guidelines" http://is.gd/adawis_guidelines (accessed Jan 24, 2016)

[3] Diu, B., Lederer, D., Roulet, B. (1989). Physique Statistique. Paris: Hermann.

(2016)

Max Planck confidently explaining a wrong theory of Uranium, 1929

Here is Max Planck confidently explaining Uranium in 1929:

"Uranium contains 238 protons and 238 electrons; but only 92 electrons revolve round the nucleus while the others are fixed in it…. The chemical properties of an element depend not on the total number of its protons or electrons, but on the number of revolving electrons, which yield the atomic number of the element."

Comment: I have always wondered how scientists thought of complex nuclei before the neutron was discovered. This statement by Max Planck must have been the best idea going in 1929, and it makes sense at some level. Protons plus "inner" electrons together inside the nucleus make a massless combination like a neutron does, whereas the "revolving" electrons dictate the chemistry and the atomic number.

Planck's description of Uranium sounds perhaps too confident, and for that maybe he could be criticized. However, any claim in science such as this should be thought of as coming with an implicitly understood preface "Our best idea going, but which could change at any moment when somebody else has a better or more efficient idea that fits the data better, is the following." I am sure Planck had this implicit preamble in mind when he wrote those words.

Reference

Max Planck. *The Universe in the Light of Modern Physics*. 1931, which is a translation of the original *Das Weltbild der neuen Physik*, 1929.

(2016)

University of Florida president rails against abuses in intercollegiate athletics and fraternities … in 1920

Nearly a century ago President Albert Murphree of the University of Florida pleaded to his fellow university presidents to rein in football and fraternities:

"Now I come to the last menace to good scholarship that I shall mention. It is probable that the emphasis which is now placed upon extra-curricular activities is one of the most potent causes of low intellectual standards. Thoughtful executives contemplate only with alarm the abuses which have crept into intercollegiate athletics, fraternities, dramatics, social affairs and student clubs of every conceivable nature."

– F.L. McVey (ed.). *Transactions and Proceedings of the National Association of State Universities*, Volume 18, 1920, pp. 51-66.

<u>Comment</u>: For many decades we have had the same "menace" to universities, ever increasing in intensity it seems, and yet we have survived and people get educated. Perhaps stability has been maintained largely because of the constant vigilance by people like President Murphree and the core of students that are very dedicated to their studies. Yet, as always, balance is the key. Extra-curricular activities at some level are good for students to maintain health and vigor.

(2014)

Montaigne describes how students are to be taught to argue

“He should be trained to choose and sift his arguments with subtlety, also to be a lover of pertinence, and so of brevity. But above all, he should be taught to yield to the truth, and to lay down his arms as soon as he discovers it, whether it appear in his opponent’s argument, or to himself in his own second thoughts. For he will not be sitting in a professorial chair to repeat a set lecture. He will be pledged to no cause except in so far as he approves it; nor will he be of that profession in which the freedom to repent and think again is sold for good ready money. ‘No necessity compels him to defend all that is prescribed and enjoined.’”

– Montaigne. *Essays*. trans. J.M. Cohen. Middlesex, UK: Penguin, 1958.

<u>Comment</u>: Interesting to note that Montaigne (1533-1592) lumps professors in the shady lot of those that will never change their minds since they have “a set lecture” they must repeat. The quote at the end of this passage is from Cicero’s Academica II,3.

(2015)

Excellent scientists can have life balance

I came across this quote about the work-life balance of Joël Scherk, who was one of the leading talents of mathematical physics in the 1970s:

"He [Scherk] used to come to his office around ten o'clock. He then took up his pad and wrote continuously except for a lunch break up to five o'clock when he put down his pad in his desk and went home. In the evenings he often studied Chinese history or some similar subject very remote from physics."

– Lars Brink in the preface of L. Brink, D. Friedan, A.M. Polyakov. Physics and Mathematics of Strings. World Scientific: New Jersey, 1990.

<u>Comment</u>: Joël Scherk was an extraordinary mathematical physicist whose impact is still felt by mathematicians, string theorists and phenomenologists despite his untimely death in 1980 at the very young age of 33. I am too young to have met him, but I have met his work. In his short career he published 8 papers that have over 500 citations and 27 papers with more than 100 citations. These were in the days where citations were harder to come by, no less. My intersection with his work has been mainly in the realm of Scherk-Schwarz supersymmetry breaking (Scherk & Schwarz 1979), which found a very nice application in supersymmetry compactified from higher-dimensional space down to 3+1. The idea is still used today to make interesting theories of weak scale supersymmetry (e.g., Craig & Lou 2014).

Students often ask me if they can be excellent scientists without 24/7 total absorption in their work, and have a life with other interests (family, hobbies, etc.). The answer is yes. The key is discipline and moderation, as this nice quote from Brink about Scherk exemplifies.

References

Craig, N., Lou, H.K. "Scherk-Schwarz Supersymmetry Breaking in 4D." arXiv:1406.4880.

Scherk, J., Schwarz, J. "Spontaneous Breaking of Supersymmetry Through Dimensional Reduction." Phys. Lett. B82 (1979) 60.

(2013)

Successful people work insanely hard

Before students get too comfortable from my last missive "Excellent Scientists can have Life Balance", here are words of advice from Ben Stein on what it takes to be successful:

"I know a lot of really successful people — in finance, in government, in politics, in Hollywood, in journalism, in literature. Their common denominator is a modicum of talent and a capacity and an eagerness … to work like Trojans to get ahead. I don't know of one really successful, famous man or woman who didn't work insanely hard to get there and stay there.

"Don't make excuses. Don't shirk. Just get to work and stay there until it's not work any more, but your life. That's success in and of itself."

Ben Stein. "Success is All in a Day's Work." Yahoo! Finance. December 22, 2006.

<u>Comment</u>: There is no doubt that this is good advice, especially when you are trying to establish your career path or reach high education goals. However, despite the exaggerated word "insane", I don't think it is necessary to have an imbalanced life to be successful. As with most good things in life, discipline is the key. Working hard takes discipline and maintaining balance takes discipline.

(2006)

Wisconsin student not impressed with the flipped classroom

A student at University of Wisconsin weighs in on the “flipped classroom” in his school’s newspaper:

“The fact of the matter is that flipped lectures do not work. Video lectures alone cannot possibly replace traditional lectures because in order to create the most effective teaching environment, the professor must be able to have physical interactions with the student body as a whole. The professor must be able to read his audience while teaching the material, so that he can tell if his students are comprehending the information he is presenting. It is no question that the best professors are those who are able to sense a lack of understanding in his or her students, no matter the size of the class, and then make corrections to his or her teaching style as needed. When the professor is teaching to an inanimate camera instead of actual students, he or she essentially destroys the final step in the communication process: feedback.”

Phillip Michaelson, “Flipped Lectures: Do not pay thousands of dollars on glorified Khan Academy Lectures.” The Badger Herald, 13 March 2015 [link].

Comment: There is much discussion recently of fundamentally changing education from a traditional lecture by a professor to students watching videos and then asking questions later. This is the so called “flipped classroom”. Excellent students can do either model. Bad students do not succeed at either. It is the vast middle where the question is sharpest. Are flipped classrooms better? The jury is out. In time we will know. But one thing data seems to be saying now is that weaker students (but not “bad students”) may be at much higher risk for dropping out and not completing a course that has too much self-initiative required to watch videos and online material. The regimented and required time to meet of a traditional classroom may facilitate higher discipline and higher completion rates.

(2015)

Spring break can lower your IQ

Spring break is arriving for most students across the country. They may wish to keep in mind Telegraph's curious report on the research of Professor Siegfried Lehrl at University of Erlangen on the ill-effects of vacation on mental acuity:

"'Fourteen days of complete rest can be enough to bring your IQ down by 20 points – more than the difference between a bright and an average student,' says Prof Lehrl. 'Vocabulary shrinks, and we even detect personality changes.'

"So how can you negate the nightmare effects of your dream vacation? According to Prof Lehrl, you should exercise your brain on holiday for at least 10 minutes a day by playing an intellectually stimulating game (chess or Scrabble, for instance), mitigate inactivity with regular long walks, rehydrate constantly – and chew lots of gum. Gum? 'The part of the brainstem that keeps us alert is constantly stimulated by chewing, as a result of which the attention level rises, as does the flow of blood to the brain."

Michael Hewitt. "Sun, sea and shrinking brain power." The Telegraph, 15 August 2011.

<u>Comment</u>: Hard to believe such things. Nevertheless, it is probably beneficial to keep up at least some reading and problem solving over an extended holiday. Forgot your books and class notes and don't know what to do? Try reading online Feynman's Lectures on Physics. Or you can just chew gum, but that's not as fun.

(2011)

All explanations end with 'it just does'

It is rather obvious but it is helpful to remind ourselves periodically that explanations only go so deep before hitting a wall, as Emmett explains:

"When we make the statement hedged about with so many qualifications it might be argued that we are making it a necessary statement by putting the necessity in; that we are saying in effect that if the wire is of such a kind that the other end will move when I pull this end, then if nothing happens to prevent it going so the other end will move when I pull this end, then if nothing happens to prevent it doing so the other end will move when I pull this. "We can couch the statement in such a form that it carries with it necessity or theoretical certainty, but the events which are being described are the events of experience. The fact that, usually, if we pull one end of a wire the other end moves is derived from experience and it is a fact which we come to see and absorb very early in life. As soon as we start touching or seeing material objects we experience events similar to this. And to the question Why it should happen no answer seems possible except that it just does. It is to events of this kind, the simplest sort of link in the chain of cause and effect, that all chains can be reduced and in terms of which they can all be explained.

"When we are investigating or analysing we want to postpone for as long as possible the answer 'It just does — it's a fact of experience — look around you and see.' And indeed one of the main points of an investigation, of asking a 'why' or 'how' question, is to discover more intermediate links. But the answer 'It just does' is bound to come eventually."

E.R. Emmett. *Handbook of Logic*. Totowa, NJ: Littlefield, Adams & Co, 1967.

<u>Comment</u>: Children, who are naturally curious, always ask "why". They ask "why" at every progressively deeper answer until their parents give up and say, "that's just the way it is!" Maybe we should answer our children with a more pleasant response that keeps their curiosity strong. For example, when we get to this point we can say, "Nobody knows why. Maybe one day you will figure that out and can tell me." I had an excellent science teacher when I was young that used to say that, and I felt so important that this teacher had the confidence in me that one day I could figure it out. He wasn't angry or frustrated with the questions, but seemed genuinely interested in knowing the answers himself. I was fortunate to have him as a teacher.

(2000)

You can still succeed in science with a non-science background

Tony Leggett won the 2003 Nobel Prize in physics for his work on superfluid helium-3. Rebecca Tan interviewed him during his visit to Singapore last month:

Tan: "You took a rather unusual path to a career in physics, doing your first undergraduate degree at Oxford in classic philosophy, known colloquially as the Greats. If you could go back in time, what career advice would you give to your 17-year-old self?"

Leggett: "Do the same, I have no regrets at all. Had I gone into physics initially, I would have missed the enormous intellectual benefits I would have gotten out of my Greats education."

– R. Tan. "A Word to Young Physicists in Asia." Asian Scientist (2 Feb 2015).

Comment: Unfortunately the world is different now. Leggett describes in this interview how he was able to go into physics based on one individual seeing some promise in him despite having almost zero background. This was at Oxford in 1959. It is very unlikely that anything like that could happen today.

The implicit question that arises from Leggett's response is whether we are greatly losing out as a field by not letting more come into the fold from alternative backgrounds. Smart people with different perspectives make a better and more energetic community overall. Who wouldn't want to see what Lionel Trilling, or Maya Angelou or Edward Said would have produced if they had become physicists?

(2015)

Longhand writing better than laptop for note taking

"In three studies, we found that students who took notes on laptops performed worse on conceptual questions than students who took notes longhand. We show that whereas taking more notes can be beneficial, laptop note takers' tendency to transcript lectures verbatim rather than processing information and reframing it in their own words is detrimental to learning."

P.A. Mueller, D.M. Oppenheimer. "The Pen is Mightier Than the Keyboard: Advantages of Longhand Over Laptop Note Taking," Psychological Science vol. 25, 1159-1168 (2014).

Comment: The implication is that the slowness of writing requires the brain to process lots of information into a smaller number of words that the student must come up with him/herself, thereby requiring more engagement with the material while being presented. Makes sense to me. It should also be noted that this is a study about today's students who are much more used to the computer than to writing. The results would be obvious for people of my age, who grew up with more longhand writing, but I presume it was less obvious to researchers that the result would stand for the very young. I hope that means spiral ring notebooks will be around forever.

(2014)

Athenodorus teaches Roman Emperor Claudius how to write well

Robert Graves channeling the 12-year-old future Roman emperor Claudius describing his lessons on writing and communicating effectively:

"Athenodorus told me [Claudius], the very first day of his tutorship, that he proposed to teach me not facts which I could pick up anywhere for myself, but the proper presentation of facts. And this he did. One day, for example, he asked me, kindly enough, why I was so excited; I seemed unable to concentrate on my task. I told him that I had just seen a huge draft of recruits parading on Mars Field under Augustus's inspection before being sent off to Germany, where war had recently broken out again.

"'Well,' said Athenodorus, still in the same kindly voice, 'since this is so much on your mind that you can't appreciate the beauties of Hesiod, Hesiod can wait until tomorrow. After all, he's waited seven hundred years or more, so he won't grudge us another day. And meanwhile, suppose you were to sit down and take your tablets and write me a letter, a short account of all that you saw on Mars Field; as if I had been five years absent from Rome and you were sending me a letter across the sea, say to my home in Tarsus. That would keep your restless hands employed and be good practice too.'

"So I gladly scribbled away on the wax, and then we read the letter through for faults of spelling and composition. I was forced to admit that I had told both too little and too much, and had also put my facts in the wrong order. The passage describing the lamentations of the mothers and sweethearts of the young soldiers, and how the crowd rushed to the bridgehead for a final cheer of the departing column, should have come last, not first. And I need not have mentioned that the cavalry had horses; people took that for granted. And I had twice put in the incident of Augustus's charger stumbling; once was enough if the horse only stumbled once. And what Postumus had told me, as we were going home, about the religious practices of the Jews, was interesting, but did not belong here because the recruits were Italians, not Jews. Besides at Tarsus he would probably have more opportunities of studying Jewish customs than Postumus had at Rome. On the other hand, I had not mentioned several things that he would have been interested to hear – how many recruits there were in the parade, how far advanced their military training was, to what garrison town they were being sent, whether they looked glad or sorry to go, what Augustus said to them in his speech.

"Three days later Athenodorus made me write out a description of a brawl between a sailor and a clothes dealer which we had watched together that day as we were walking in the rag-market; and I did much better. He first applied this discipline to my writing, then to my declamations, and finally to my general conversation with him. He took endless pains with me, and gradually I grew less scatter-brained, for he never let any careless, irrelevant, or inexact phrase of mine pass without comment.”

Robert Graves. *I, Claudius*. Penguin Books: London, 1986.

Comment: These are very good lessons on writing scientific papers as well. Among the writing sins implied above, repetition and getting side-tracked off the main argument are perhaps scientists’ biggest writing sins. However, repetition is often viewed as a good technique to emphasize the main points of the paper. Claudius, or rather Robert Graves, would disagree.

(2009)

Difference between a cathedral and a physics lab?

“What have we been doing all the centuries but trying to call God back to the mountain, or, failing that, raise a peep out of anything that isn’t us? What is the difference between a cathedral and a physics lab? Are they not both saying: Hello?”

Annie Dillard. *Teaching a Stone to Talk*. Harper Perennial, 1992.

Comment: It is often remarked that physics and mathematics are dreary subjects that are impersonal and lonely. Humans are a social species, who crave contact, discussion, gossip, and interactions of all kinds with people. History, psychology, social science, medicine, and law are all fields that “make sense” from this perspective. What drives the physical scientist and the mathematician? It is a craving to discover the “other” — that which is greater and more enduring than even our personal lives.

(2007)

Study of nature far superior to other human activities?

Cicero channeling Pythagoras on the value of studying nature:

"Some of us are enslaved to glory, others to money. But there are also a few people who devote themselves wholly to the study of the universe, believing everything else to be trivial in comparison. These call themselves students of wisdom, in other words philosophers; and just as a festival attracts individuals of the finest type who just watch the proceedings without a thought of getting anything for themselves, so too, in life generally, the contemplation and study of nature are far superior to the whole range of other human activities."

Cicero, "Discussions at Tusculum", in Cicero's *On the Good Life*. Penguin, 1971

Comment: It should be remarked that Cicero invokes Pythagoras here as getting it almost right, but later says that Socrates, whom Cicero deeply admired, had it right when he "took the initiative in summoning philosophy down from the heavens." In the end, according to Cicero (On Divination, II), there is but one source of real happiness. It is the "proposition which brilliantly illuminates the entire field of philosophy — the proposition that moral goodness, by itself, is sufficient to make anyone happy." Nonetheless, I've met many physicists who appear to agree more with Pythagoras than Cicero, and of course many who appear to agree with both. After all, the two are not incompatible.

(2015)

On eliminating the university lecture, from Nabokov's Pnin, 1957

Recently there has been much discussion about radically reforming university education. Many of these reforms advocate the elimination of the lecture. The Atlantic magazine profiled last August the upstart Minerva Project, which is a "university" predicating itself on no lectures. This is thought to be revolutionary and new to our times.

However, anybody who has been in the education business knows that these ideas and close variants of them have been talked about and tried and abandoned and tried again for many decades, if not centuries. My personal view is that social science researchers' ability to quantify the value of a proper lecture may be severely lacking. But that discussion is for another time. Instead, what I wish to do is demonstrate how long-standing this debate is.

At the end of this post I give an early reference from 1957 of professors discussing the elimination of the lecture. It is written by Vladimir Nabokov in his novel Pnin. Nabokov of course is the famous writer of Lolita and other outstanding literary works. He also emigrated to the United States and taught at Wellesley College and Cornell for more than 18 years. Pnin is a semi-autobiographical account of a Russian emigré literature professor taking up a non-tenured teaching post in Waindell College in New York. Timofey Pnin is lonely, devoted to his scholarly work, frustrated with his lazy American students, and somewhat clueless about the political machinations around him. Toward the end of the book he throws the academic party of the decade at his college, only to be told after it by a colleague that he will be out of his job by the next year.

It is at this academic party that three university professors at Waindell college get into a discussion about their frustrations in educating students. Hagen ventures after a few drinks to tell his colleagues his view that the lecture should be eliminated. Instead "phonograph records" should be made available once and for all. Not too different than us saying today that a video should be made once and for all, and no more lecturing ("flipped classroom"). It degenerates into teasing hapless Timofey Pnin, the host of the party, by saying, "The world wants a machine not a Timofey."

Clements is the voice of teaching orthodoxy and his style is to put his own strong words into someone else's mouth (Tom) and to make jokes to lighten the discussion ("We could have Timofey televised"). He ends the discussion with a dismissive "sure, sure" when Tom protests and implies that there is something to Hagen's ideas of eliminating the "old-fashioned lecture."

Nabokov was surely familiar with such debates during his time as professor at Wellesley and Cornell in the 1940's and 1950's. It is the same debate we are having today, sixty years later. Whatever position you might have on this question, keep in mind that it is not a new debate, and there may be reasons why changes advocated by the Hagens of the world were not so quick coming.

Excerpt from chapter 6 of V. Nabokov's Pnin, 1957 (character descriptions given in brackets):

At a still later stage of the party, certain rearrangements had again taken place. In a corner of the davenport, bored Clements [philosophy professor] was flipping through an album of Flemish Masterpieces that Victor [son of Pnin's ex-wife] had been given by his mother and had left with Pnin [Timofey Pnin]. Joan [Clements's wife] sat on a footstool, at her husband's knee, a plate of grapes in the lap of her wide skirt, wondering when would it be time to go without hurting Timofey's feelings.

The others were listening to Hagen [German professor] discussing modern education:

"You may laugh," he said, casting a sharp glance at Clements—who shook his head, denying the charge, and then passed the album to Joan, pointing out something in it that had suddenly provoked his glee.

"You may laugh, but I affirm that the only way to escape from the morass—just a drop, Timofey: that will do—is to lock up the student in a soundproof cell and eliminate the lecture room."

"Yes, that's it," said Joan to her husband under her breath, handing the album back to him.

"I am glad you agree, Joan," continued Hagen. "However, I have been called an enfant terrible for expounding this theory, and perhaps you will not go on agreeing so easily when you hear me out. Phonograph records on every possible subject will be at the isolated student's disposal …"

"But the personality of the lecturer," said Margaret Thayer [wife of English professor Roy Thayer]. "Surely that counts for something."

"It does not!" shouted Hagen. "That is the tragedy! Who, for example, wants him"—he pointed to radiant Pnin—"who wants his personality? Nobody! They will reject Timofey's wonderful personality without a quaver. The world wants a machine, not a Timofey."

"One could have Timofey televised," said Clements.

"Oh, I would love that," said Joan, beaming at her host, and Betty nodded vigorously. Pnin bowed deeply to them with an "I-am-disarmed" spreading of both hands.

“And what do you think of my controversial plan?” asked Hagen of Thomas [anthropology professor].

“I can tell you what Tom thinks,” said Clements, still contemplating the same picture in the book that lay open on his knees. “Tom thinks that the best method of teaching anything is to rely on discussion in class, which means letting twenty young blockheads and two cocky neurotics discuss for fifty minutes something that neither their teacher nor they know. Now, for the last three months,” he went on, without any logical transition, “I have been looking for this picture, and here it is. The publisher of my new book on the Philosophy of Gesture wants a portrait of me, and Joan and I knew we had seen somewhere a stunning likeness by an Old Master but could not even recall his period. Well, here it is, here it is. The only retouching needed would be the addition of a sport shirt and the deletion of this warrior’s hand.”

“I must really protest,” began Thomas.

Clements passed the open book to Margaret Thayer, and she burst out laughing.

“I must protest, Laurence [Clements],” said Tom. “A relaxed discussion in an atmosphere of broad generalizations is a more realistic approach to education than the old-fashioned formal lecture.”

“Sure, sure,” said Clements.

(2013)

Factors that determine success in learning

At the start of the new academic year many first-year university students will find that they must sharpen their study skills to be successful in demanding majors. I came across an edition of “Student Success” by Walter and Siebert (1990) which gives excellent advice to those who wish to “succeed in college and still have time for [their] friends.”

In their survey of the research literature they found ten factors that students should know when attempting to learn and remember new material:

“Information can’t be remembered when it isn’t learned well.”

“Recognizing the material read is not the same as learning for recall. Recognition is the easiest learning; recall, the most difficult.”

“You don’t learn or retain information well if you are distracted. Noise, television, music, and people talking all divert part of your brain’s attention from what you are studying. Being preoccupied or worried can also distract you from learning and remembering.”

“Information does not transfer from short-term memory to long-term memory without effort, repetition, and practice.”

“Your memory of information lasts longer when learning is spread out over a period of time.”

“Your ability to remember information drops very sharply following the learning. Al- though the main points of a morning lecture may be recalled while talking to a friend at lunch, much of what was learned will be forgotten two weeks later. Only a small percentage of information is retained if you do not use it or practice relearning it.”

“Trying to learn too much information too fast interferes with accurate recall. The nervous system needs time to assimilate new learning before taking in more.”

“Information recently learned will be interfered with by similar information learned soon after. This is a process called retroactive inhibition, in which you have difficulty recalling new information too similar to other new information.”

“When you have an emotional dislike for the material being learned, you will have difficulty recalling it objectively and accurately.”

“Learning and remembering are less efficient when you lack interest in the material or motivation to learn.”

In addition to knowing what it takes to learn and remember new material, they also state that active time management is a key to success. Here are a few of the questions they pose that one should answer "yes" to in order to increase the odds of success:

• "Have I outlined a weekly study schedule for myself?"

• "Do I write out and follow daily time schedules?"

• "Is my study free of distractions?"

• "Do I avoid studying one subject too long?"

• "Do I record my progress at achieving study goals?"

• "When I achieve study goals, do I reward myself?"

Good luck students in the new academic year!

Reference

Walter, T., Siebert, A. 1990. *Student Success*, 5th ed. Chicago: Holt, Rinehart and Winston.

(2001)

In praise of theory and speculation

I once heard a famous and well-decorated experimental physicist say that experimentalists simply shouldn't listen to theorists at all. Experimentalists should just measure and things will come what will, and they should pay no attention to theorists' speculations and arguments at all when deciding what experiments to do.

I was very young and inexperienced at the time, but thought then as I do now that it was a dangerous and silly philosophy. There are so many examples of how it pays for communication to go both ways, theorists paying close attention to what experimentalists say and experimentalists paying close attention to what theorists say.

An example that I was reminded of recently is of an experimental collaboration that was building up steam to look for invisible orthopositronium decays. One argument was that the electron and positron could annihilate into extra dimensions. However, Friedland and Giannotti (arXiv:0709.2164) showed that such decays would be disastrous to supernova cooling rates, and that the proposed experiment was essentially guaranteed to not find anything. In other words, a waste of time and money, and a huge opportunity cost to the experimentalists involved. The anti-theory philosophy would say, "Don't listen to those theorists! Just do it! Measure what you can and want to measure!" which would be clearly bad advice here. If there were infinite numbers of people and dollars, that might not do harm (I doubt it then too), but in the present world, it is more prudent to pursue our best bets, guided by theory.

Regarding best bets, it should be noted that the Higgs boson was pure speculation until it was discovered recently. It was, gasp, just a theory model! It had no direct experimental support, and alternative theories without the Higgs boson abounded. Yet, luckily, there were experimentalists who sorted through the alternatives to decide on a best bet, with theory guidance, and then designed fantastic detectors and experiments and search algorithms focused on finding it. Without that sustained dedication to this speculation they would not have succeeded.

And anyway, theory and speculations are what give joy to intellectual pursuits. Theory haters are unhappy people, and happy people are more productive, so unleash your speculations and theories. If you won't listen to me, let John Steinbeck (1969) encourage you:

"There are some people who deeply and basically dislike theories and are hostile to speculations. These are usually unsure people who, whirling in uncertainties, try to steady themselves by grabbing and tightly holding on to facts. Speculation or theory-making on the other hand is simply a little game of pattern-making of the mind. The theory hater cannot believe that is important. To such a person a theory is a lie until it is proven and then it becomes a truth or a fact. But there's no joy in it."

Reference

John Steinbeck. *Journal of a Novel: The East of Eden Letters*. Viking Press, 1969.

Stanford University president compares American and German students, 1903

Having spent a lot of time at German universities and American universities, I was amused by a passage written in 1903 by Stanford University's first President David Starr Jordan. Qualitatively I think some of what he said in 1903 applies today, although he was surely much too harsh on the German boys. It smacks of resentment that he really thought German boys were better than ours, and he tried hard to find reasons why we might be better, even though as a University president I'm sure he wished Americans were more academically inclined.

Also, I wonder if in 1903 it was the same as today, that American students and American education has a significantly higher variance than students and education in Germany. This is widely recognized today, but Jordan doesn't mention that. I suspect that it was the case back then also – think Little House on the Prairie schoolhouses versus fancy New England Prep Schools. And the quip about American westerners being more broadly knowledgeable about practical things of the world still holds true today I think. In my extended family, Western Americans can change plumbing, build a deck, and replace a muffler, but Easterners have to call somebody when the refrigerator light goes out.

Here's the passage:

"It is true that in the gymnasium [academic track German preparatory high school] students get on faster than in our high schools and preparatory schools. The German student is as far along in his studies at sixteen as the American at eighteen. This is due to the fact that American life makes more outside demands on boys than life in Germany does. The American boy is farther along in self-reliance and in knowledge of the world at sixteen than the German at twenty. The American college freshman, especially if brought up in the West, knows a thousand things, outside of his books and more useful, because more true than most of what his books contain. He can ride, drive, swim, row, hunt, take care of horses, play games, run an engine, or attend to some form of business, while the German boy cannot even black his own shoes" (Jordan 1903).

Reference

David Starr Jordan. *The voice of the scholar, with other addresses on the problems of higher education*. San Francisco: Paul Elder & Co, 1903.

(2011)

Advice from the Soviet Union on how to become a great physicist

Whatever you might think of the Soviet Union, they undeniably had incredible physicists. There are many reasons for this, but a culture of grit and personal determination to tackle physics problems on one's own appears to me to be one of the key factors. To illustrate, here's a quote from I.V. Savelyev, author of the three-volume "Physics. A General Course," a successful Soviet-era textbook of undergraduate physics:

"The solving of problems will yield the maximum returns only if a student does this it by himself. It is often not easy to solve a problem without any aid or prompting, and this is not always successful. But even unsuccessful attempts to find a solution, if they were undertaken with sufficient persistence, will give noticeable returns because they develop thinking and strengthen one's will power. It must be borne in mind that the decisive role in working on problems, as in general in studying, is played by will power and diligence."

I.V. Savelyev. *Questions and Problems in General Physics*. Mir Publishers, Moscow, 1982 (English 1984).

(2012)

University enrollment pressures of the 1930s and Kinsey's sexual revolution

America in the 1920s was one of the most fascinating times in our history, as we transitioned so rapidly from a backwards country to an intellectual, cultural and economic powerhouse. It was a time where freedom of individual expression was flowering, and cultivation of the individual mind was starting to be valued. It is no wonder to me that some of the first greatest physics results from America came in the 1920s. I think of the Davisson-Germer experiment published in 1927 (Davisson & Germer 1927) as one of the key scientific discoveries that roughly marks the beginning of top-flight American physics research. This particular result established for the first time that electrons act like waves, and was central to the development of quantum mechanics.

This rapid rise of the American higher educational landscape started in the 1920s. Many more students were graduating from high school than ever before (Kyvig 2001). This put tremendous pressure to expand universities, increase enrollments, and hire more faculty:

"By 1940, half of all eighteen year olds [obtained] a high school diploma, triple the percentage who had done so merely twenty years earlier. The increase in high school graduates together with the growing demand for better-educated teachers helped stimulate a significant rise in college attendance during the 1920s and 1930s. The overall enrollment grew from 600,000 to 1.5 million. Most of the enrollment growth involved middle-class students attending non elite public universities in the Midwest and elsewhere" (Kyvig:2001).

The schools in the Midwest were much larger than the east coast "elite" schools, and they also were co-educational, a somewhat new development in the country, as least regarding the magnitude of coeducational instruction.

"Like secondary schools, colleges and universities underwent curricular reform and expansion in the years between the world wars. As the number of faculty tripled, the variety of courses increased proportionally. Courses and programs in business, engineering, fine arts, and education and new approaches to the study of human society such as anthropology, political science, and sociology were added to the traditional arts and sciences, medicine, law, and theology. Courses [were] designed to prepare students for the ordinary routines of everyday life, gradually becoming as straightforward and frank as the popular Indiana University course on marriage begun by Professor Alfred Kinsey in 1938, also entered the catalogue" (Kyvig 2001).

I found it interesting that the big, practical courses that universities so often have now for younger students (freshmen and sophomores) were initiated during the grand expansion of the university curricula in the 1930s. I also did not know that Alfred Kinsey, who is most famous for his scholarly, yet bestselling, 1948 book

“Sexual Behavior in the Human Male,” was one of the leading “star professors” to develop a large enrollment course at Indiana University, as part of this new national trend.

Kinsey did not exactly stumble upon this role. He was led to it by a set of negative events outside of his control that he responded to positively:

“Kinsey was deeply disappointed that he was not offered a professorship at a more prestigious university. Perhaps because of this disappointment, Kinsey made an unusual career move in 1938: he agreed to lead a team-taught course on marriage and the family instituted in response to a student petition. High points of the course were Kinsey’s illustrated lectures on the biology of sexual stimulation, the mechanics of intercourse, and the techniques of contraception, as were his spirited denunciations of repressive laws and social attitudes. The Indiana students responded enthusiastically, and his course enrollments grew to 400 by 1940” (Brown & Lee 2003).

At the time he was initiating this course, and seeing the tremendous interest of the students in such “practical things” he shifted his research interest just as dramatically. As Brown and Fee tell us, “Kinsey now shifted his research focus as well, transferring his obsessive concern with variation among gall wasps to the varieties of human sexual experience. He required students in his marriage course to have private conferences in which he took their sexual histories. On weekends and vacations, he conducted similar interviews in nearby communities, and later in such cities as Gary, Chicago, St. Louis, and Philadelphia. In January 1948 [ten years after his course began], Kinsey and his collaborators published Sexual Behavior in the Human Male” (Brown & Lee 2003).

Kinsey's highly recognized research leads Brown and Fee, and most others, to conclude that he was “one of the most influential Americans of the 20th century” who “helped usher in the ‘sexual revolution’ of the 1960s and 1970s” (Brown & Lee 2003). Thus, it appears that the enrollment pressures at universities in the 1930s, combined with Kinsey’s frustrated ego, made it attractive and possible for Kinsey to start his new career in frank sexual teaching and research, which ultimately influenced so many through his blockbuster selling books of the late 1940s and 50s, helping facilitate the rise of the sexual revolution decades later.

References

C. Davisson, L.H. Germer (1927). “Diffraction of Electrons by a Crystal of Nickel.” Physical Review 30, 705.

David E. Kyvig (2001). *Daily Life in the United States, 1920-1939*. Westport: Greenwood Press.

T.M. Brown, E. Fee (2003). “Alfred C. Kinsey: A Pioneer of Sex Research.” Am J Public Health 93, 896.

(2013)

Completing Hirsch's h-index measuring scholarly impact

Ranking an individual's research impact is very hard. Unfortunately that's what administrators at universities and laboratories worldwide must do. Who should get more pay? Who should get tenure? Who is more impactful in the world of scholarship? It is seemingly impossible, yet we try anyway.

There is a temptation to take somebody's entire research portfolio and boil it down to one number so that he or she can be ranked more easily with others. One approach is just to count number of papers published, but this makes no sense at all with the rise of "predatory journals," and the willingness of many otherwise good journals to expand beyond reason to make room for low quality work beside high quality work.

Another number used in the past was total citations to research articles. Or in other words, how many times did somebody else write their own research paper and cite you in it. You are considered better if you have a higher number of citations to the body of your work. However, this isn't fair to young people who have not been in the field long, and who have not accrued a large number of citations over time despite perhaps being much better than an older researcher.

Another measure to rectify that is average citations per paper. This doesn't punish the young people as much, because if you have written 5 papers with 200 citations each on average, which makes a total of 1000 citations, it is probably a more impactful career, and a better scholar, than an older colleague who has written 200 papers over decades with only 5 citations each.

However, the problem with citations per paper is that an older person could have written a paper from 30 years ago and get a cagillion citations that accrue every year and not have to do anything more. Their career, and funding, and pay raises, and respect, would be based on interest payments of a good investment decades ago. That is not fair either.

And with this in mind Hirsch introduced [1] the "h index." A researcher's h index value is when they have written at least h number of papers with at least h citations for each paper. This is a nice compromise between consistent value and total citations. A researcher can have a huge number of citations accrued from a paper in 1977 but have a small h index.

The h index has taken universities by storm. Everybody wants to know a person's h index as the most important single number characterizing their research impact. That is not to say that people do not understand the limitations. Some fields are huge with very large numbers of references in each paper, which inflates the h-index. Other fields have a huge number of authors, and get themselves on a quasiinfinite number of papers (high-energy experimentalists), many of which they have barely read. Their h index shoots up all the same.

Even within a subfield you can have vast differences in how easy it is to get citations and increase the h factor. For a while in particle theory if you had the words "ADS/CFT" or "Neutrinos" anywhere in your title, it automatically meant 50-100 citations. If you ambulance chase — meaning you wrote a paper very fast on an experimental anomaly — you often get very large numbers of citations. That is playing out in the cosmology community right now. There is a citations bonanza for all papers discussing the tensor mode fluctuations of the cosmic microwave background radiation perhaps seen by the BICEP2, or perhaps not.

But do not get me wrong, I think "piling on" for an interesting theory direction or experimental result is entirely appropriate. Experiments cost many millions or even billions of dollars and when results come they should be payed attention to, and focus should happen. And when an incredible theory discovery like the ADS/CFT correspondence comes along, researchers should squeeze it for everything it's worth. It is nobody's fault, and it is not dirty, that citations come from this. Trends in research are healthy to really crush the subfield and get all the meaning out that one can. I get annoyed by people who think that a sure proof of original thinking is that nobody cares or cites the paper. (They usually don't phrase it that way, but that's the upshot.)

Anyway, on a recent visit to the University of Michigan Keith Dienes and I had a discussion about these matters. In the process he told me some of his very interesting insights regarding the h factor. He recognizes that the h factor as a single number measure of scholarly impact is perhaps better than anything else we have that is widely recognized and understood, but suggested how the h factor's utility could be greatly improved or "completed" in a conceptually straightforward way. The fundamental observation he made, which is something a good physicist would think of, is that "numbers of papers" and "citations" are different units. The h factor assumes that the conversion between these two units is always 1, but there are circumstances where that is entirely inappropriate and the h factor then carries no worthwhile meaning. The conversion factor must be calculated for each field, and ideally for each subfield to really measure the impact.

He has been encouraged to write up these thoughts (including by me), since this is such an important consideration at universities these days. Now the paper has appeared on the arXiv [2]. Anybody who is required to think about how impactful researchers are across different fields and even subfields may find it very helpful to read this interesting and insightful paper.

References

[1] J.E. Hirsch. Proc. Nat. Acad. Sci. 46, 16569 (2005). arXiv:physics/0508025.

[2] K.R. Dienes. Completing h. arXiv:1404.2603.

(2014)

Student petitions his professor, Russia 1899

One of the things that literature can do that is hard to replicate otherwise is to give a boots-on-the-ground feel for what life was like in a different era. Being a professor, I am especially interested in what university life was like at different times and in different places.

Recently I came across Anton Chekhov's fascinating 1899 first-person novella "The Dreary Story" about a distinguished professor of medicine, Nikolay Stepanovitch, reflecting on his life, and recounting the daily banalities near the end of his career. He chronicles his interactions with colleagues, his preparation and delivery of lectures, his thoughts on the value of education, his thoughts about who will become great researchers and who will not and why, and thoughts about students. It is a fascinating read for anybody involved in education, both students and teachers.

Chekhov was a physician by training, and was not many years removed from his schooling when he wrote this novella just shy of his 30th birthday. He also was a tutor for some time, and so had close contact with a multitude of students's abilities, ambitions and life stories. The acuteness of Chekhov's observations combined with his recent close connection to higher education adds interest for me in this story.

There is one section that is particularly interesting with regard to student interactions with the professor. It reports of a "sanguine youth" visiting Professor Stepanovitch during office hours, asking to be passed on an examination. Professor Stepanovitch denies the student a passing grade, and during the recounting of this appeal reveals to the reader his unflattering thoughts about the student: he is more interested in beer than thinking, has no real commitment to medicine, lies on the couch most of the day, and could tell you much more about "the opera, about his affairs of the heart, and about comrades he likes" than about his studies. There are any number of modern-day unproductive diversions for students that could substitute for what Chekhov meant by "opera", such as following sports, pop stars, reality shows, movies, and other activities that have very little lasting value for the individual and present a huge opportunity cost when pursued to excess. Professor Stepanovitch's thoughts fit well with what gives today's professors concerns about some current students.

There is a moment when the student tries to give his "word of honour" that if he is given a passing score he will ____, but the student never finishes the thought, because Professor Stepanovitch has already waived his hands and sat down, signaling to the student that he has heard it before and he will not buy whatever the student is about to say. And what could the student have said? There are not many options. Perhaps the student is wishing to say, "I will keep learning it over time and will make sure that it never hurts my ability to practice good medicine. Just pass me on this last hurdle, and I will be on my way and make you proud. You'll see. I promise."

The professor will have none of that. It is often a young person's fundamental confusion to believe that it is convincing to say "give me this thing I really want, and then I promise to do something good," whereas life really works mainly in the other direction, "do something good, and then you will get something more." Professor Stepanovitch ends his recounting of the office visit with a devastating unspoken send-off to the student: "Peace be to thy ashes, honest toiler." He counts the student among the living dead, who will never understand and will never amount to anything.

It is a cynical story but presumably evokes well what Chekhov understood and saw in late 19th century Russia. So for all you students out there, if you eagerly sat through ESPN's full coverage of "signing day" for college football, or if you are keeping up with the Kardashians, and you compromised success in the classroom in any way because of it, remember what Professor Stepanovitch would say, "Peace be to thy ashes."

On the other hand, this story is from the perspective of a professor, who values, or at least has been conditioned over time to value, intellectual pursuits and academic success above anything else. There are more paths to a successful life than Professor Stepanovitch is able to admit, but he is surely correct that an imbalance of beer, "opera", football, Kardashians, etc., are not compatible with the pursuits of higher academics or of intellectually intensive professions such as medicine. Young people have to choose.

(2013)

Heisenberg's Failed Prophecy for Particle Physics

Prominent politicians and writers have opined recently that the era of fundamental discoveries in the physical sciences has ended. It is especially troublesome to hear related views expressed by some of our distinguished colleagues. Usually the attacks are toward one particular subfield by a member from another subfield. Particle physics has been just one of the targets of this confused thinking.

Extreme pessimistic views about science progress have been with us since the very beginning of science. Distinguished scientists in their later years are not uncommon proponents. One example is Werner Heisenberg's view of particle physics in the late 1950's and early 1960's. It is instructive to see how little the arguments have changed against particle physics over more than four decades despite the staggering accomplishments the field has made since then. Heisenberg's fully developed views are summarized most succinctly in his 1963 talk, ``The Present Situation in the Theory of Elementary Particles'' delivered in Copenhagen.

Although Heisenberg did not have significant direct impact on particle physics progress in the post-war years, he was still an active researcher well into his sixties. His amazing pre-war discoveries in quantum mechanics put him permanently in the club of scientific genius and Nobel laureates who deserved to be taken seriously. Heisenberg's talk covered many interesting topics including the role of local field operators in any sensible axiomatic theory, the usefulness of symmetry classifications (isospin, parity, etc.), and the ubiquity of broken symmetries of the ground state. He clearly had an expert overview of the field.

Heisenberg was less impressive when he tried to extrapolate the current knowledge into a vision for the future of the field. A major theme in his talk was that the era of high-energy physics was over. Although he hedged slightly here and there on making this claim too strongly, he said it with as much force as an esteemed scientist can say anything speculative and still sound reasonable.

He began the talk by asking the rhetorical question, What is an elementary particle? The old answer to this question says that elementary particles are the smallest indivisible units of matter. The past brought the successes of watching bulk material reduced to atoms, atoms reduced to electrons and nuclei, and nuclei to protons and neutrons. The trend must continue indefinitely, it would seem to the naive observer.

But the reductionist trend has ended, according to Heisenberg. The "big accelerators" at Berkeley, Dubna, Geneva, and Brookhaven were only seeing more of the same stuff. The particles they were seeing were "not smaller units of matter", but rather "the same kinds of elementary particles." He admonished his fellow scientists to not think of elementary particles as a collection of fundamental building blocks. Instead, they are "just different forms of the same 'substance'." He further claimed that all the elementary particles were likely to be merely stationary states of a "system matter" analogous to energy levels of an atom. "No distinction can be made in principle between an elementary particle and a compound system," he claimed.

These perspectives, which he was quick to emphasize derive from experimental results, lead to an almost inescapable conclusion in Heisenberg's view:

> *If these results will be confirmed, it would mean that at the elementary particles we have actually come to an end in dividing matter. Any further 'division' or 'splitting' of elementary particles would not lead to new or smaller particles; it would be pointless to use higher and higher energies in collisions, because nothing new will happen.*
>
> *This final result is not yet certain, but it looks rather probable. If it turns out to be correct, it would not mean that physics has been closed. Physics would be closed only at the limit of highest energies or smallest spatial dimensions. It would still be open in the limit of very large spatial dimensions (cosmology) or very large particle numbers (biology).*

Comments were recorded at the end of the talk, and Victor Weisskopf strongly objected to the view that high-energy physics was over. Weisskopf emphasized that "the universe presents us with possibilities that we just don't know of.'' Of course, we know now that Weisskopf was right.

Since that conference, quarks and asymptotic freedom have been discovered. The Fermi model of weak interactions has been pulled apart and explained by a spontaneously broken SU(2) gauge symmetry. More exotic quarks have been discovered, including the top quark whose mass is well into the energy realm where Heisenberg thought things would be uninteresting. Only very recently did we have well-posed questions about the origin of mass and gauge symmetry breaking, and it is widely agreed that present and future experimental pursuits will further enlighten us to answer these questions. We also believe we are making progress understanding how quantum mechanics and gravity coexist. The insights in particle theory have transferred over to cosmology, and vice versa, in completely unanticipatable ways from Heisenberg's day.

In most ways our current situation in particle physics is much more interesting than the state of particle physics those many years ago. We have readily identifiable big-question holes in our knowledge that we are confident experiment can fill. It did not seem so promising in that era, where the elementary particles looked like an endless herd of cattle kept in line by a limping sheepdog named Regge Theory, yet only a decade after Heisenberg's talk the Standard Model of particle physics was established.

Although Heisenberg was somewhat isolated by his own idiosynchratic theories, he was not alone in the general pessimistic view that future experiments were not likely to change the basics of our understanding. I see some parallels today. The overly confident optimist might be a little humorous, but the overly confident pessimist ``runs a danger'' as Weisskopf said after Heisenberg's talk those many years ago. The tremendous knowledge we have attained regarding the high-energy domain in the last few decades came at least in part because Heisenberg's bleak views in the 1950's and 1960's did not stop experiment.

For physicists like me, educated in the 1990's, it is not much of an exaggeration to say that modern high-energy physics starts becoming recognizable around the early 1970's. In Heisenberg's era it was difficult to even recognize the questions that would become relevant for the later discoveries, much less be able to figure out the correct answers. Experiment was critical for progress, and future experiments at the frontiers of energy, intensity and precision will continue to stimulate deeper knowledge about the underlying laws of nature.

(2002)

Cicero on cosmology in Roman antiquity

Cicero in about 50 BCE explaining the heavens:

"The universe is held together by nine concentric spheres. The outermost sphere is heaven itself, and it includes and embraces all the rest. For it is the Supreme God in person, enclosing and comprehending everything that exists, that is to say all the stars which are fixed in the sky yet rotate upon their eternal courses. Within this outermost sphere are eight others. Seven of them contain the planets ? a single one in each sphere, all moving in the contrary direction to the great movement of heaven itself. The next sphere to the outermost is occupied by the orb which people on earth name after Saturn. Below Saturn shines the brilliant light of Jupiter, which is benign and healthful to mankind. Then comes the star we call Mars, red and terrible to men upon earth.

"Next, almost midway between heaven and earth, blazes the Sun. He is the prince, lord and ruler of all the other worlds, the mind and guiding principle of the entire universe, so gigantic in size that everything, everywhere, is pervaded and drenched by his light. In attendance upon the Sun are Venus and Mercury, each in its own orbit; and the lowest sphere of all contains the Moon, which takes its light, as it revolves, from the rays of the sun. Above the Moon there is nothing which is not eternal, but beneath that level everything is mortal and transient (except only for the souls in human beings, which are a gift to mankind from the gods). For there below the Moon is the earth, the ninth and lowest of the spheres, lying at the centre of the universe. The earth remains fixed and without motion; all things are drawn to it, because the natural force of gravity pulls them down.

Comment: This passage was originally written by Cicero sometime between 54 BCE and 51 BCE. The "Dream of Scipio" is in the last volume of his six volume set entitled On the State. Much of those six volumes is lost to us now. However, we do know that the device Cicero used was that of a conversation between Scipio Africanus the younger and others. The passage above is Scipio Africanus the elder coming in a dream to explain the heavens. It is a nice summary of what Romans of antiquity knew and thought of astronomy and cosmology. Of course, Cicero got much of this from the Greeks, but he had to synthesize sources and make decisions, especially on the ordering of the planets and the Sun (he sided with Pythagorus over Plato). Presumably he consulted with others as well, and it is fair to say that this is likely to be the Roman view of the cosmos in approximately 50 BCE.

Reference

Cicero. "The Dream of Scipio," in Cicero's *On the Good Life*. Penguin, 1971.

(2013)

Strict oversight at Collège de Dainville, Paris, 1380

Students in residence at the Collège de Dainville (founded in 1380 and part of the Université de Paris) were subject to very strict study rules:

“Day and night, until they go to bed, the door is not to be closed, so the master can visit whenever he wishes and so that the pupils will increase their zeal for study and fear to fall into idleness or bad habits. If he deems it necessary, the master shall be allowed to hold the key to each room.”

G. Duby, ed., trans. by A. Goldhammer. A History of Private Life, vol.II: *Revelations of the Medieval World*. Belknap Press, 1988. As quoted by P. Lin. “Student Life”. Cal Poly Pomona.

(2014)

Teach with enthusiasm and devotion

Some interesting advice on teaching from former president of Swarthmore College:

“Be sure you have in your faculty teachers of enthusiasm, energy, devotion to their calling, well trained in a knowledge of the subjects which they teach, who by example as well as precept instill lessons of continuous and fruitful work. If the teacher is half-hearted, dry and uninteresting, if he is not himself a student and a hard worker, there is little inspiration from such a teacher for effort on the part of the student. On the other hand, if the teacher never forgets the point of view of the learner, by always being himself a learner, has the vigor which comes from constant growth, and is as much interested in the development of intellect and character in young people as the botanist is in the growth of the plant, the teacher will place about the student the conditions for effort and offer an incentive to hard work.” (p.43)

“If the teacher is himself methodical and lays out the work of the student in such a way that he feels strongly that he has a definite piece of work to do today and he knows that he will be very definitely tested tomorrow by his teacher before the students on this work in the class room, an otherwise indolent student will be spurred to work.” (p.44)

Reference

Joseph Swain (President of Swarthmore College). “Methods of correcting or eliminating idle or unprofitable university students.” *Transactions and Proceedings of the National Association of State Universities*, 1903.

(2014)

Examine your students properly

Admonition about the importance of exams for students given by former president of University of Nebraska:

“Apathy about examinations is a crying evil. Some institutions only quiz, and do not, properly speaking, examine at all, neglecting a vitally precious mental discipline, that of acquiring master over subjects as wholes, and over parts in their relations to each other and to the totals. The examination of a pupil upon a large unit of his work is of advantage not merely as criterion of his diligence or proficiency, though it may and should be this; it is a pedagogical process of indescribable value, not to be omitted without cruelty to the pupil.” (p.26)

Reference

Chancellor E. Benjamin Andrews (University of Nebraska). “Current Criticism of Universities. *Transactions and Proceedings of the National Association of State Universities*, 1905.

(2014)

Higher talent required to explain broadly than to impart specialized knowledge

Former president of University of Nebraska talks about the skills needed to explain a topic broadly without specialized jargon.

"American universities present few courses of this most useful order. Learned men often seem to think it beneath them to construct general courses, a whim which Lombroso might cite as another proof that genius and insanity are twins. With all respect for microscopic specializing, earnestly to be encouraged in every way, I so far risk my life as to say that it takes higher talent to frame a good course on the salient facts and laws of biology as a whole, than it does to frame a good course on the possible significance of a suspected new convolution in the superior anterior lobe in the brain of a rare species of butterfly." (p.29)

Reference

Chancellor E. Benjamin Andrews (Univ of Nebraska). "Current Criticism of Universities." *Transactions and Proceedings of the National Association of State Universities*, 1905.

(2014)

Student evaluations of teaching are of limited value

Here are Stark & Freishtat's conclusions that call into question the value of student evaluations of teaching (SET):

"SET does not measure teaching effectiveness."

"Controlled, randomized experiments find that SET ratings are negatively associated with direct measures of effectiveness. SET seem to be influenced by the gender, ethnicity, and attractiveness of the instructor."

"Summary items such as 'overall effectiveness' seem most influenced by 20 irrelevant factors."

"Student comments contain valuable information about students' experiences."

"Survey response rates matter. Low response rates make it impossible to generalize reliably from the respondents to the whole class."

"It is practical and valuable to have faculty observe each other's classes."

"It is practical and valuable to create and review teaching portfolios."

"Teaching is unlikely to improve without serious, regular attention."

Reference

P.B. Stark, R. Freishtat. "An Evaluation of Course Evaluations." September 26, 2014. http://www.stat.berkeley.edu/~stark/Preprints/evaluations14.pdf

(2015)

Advice on becoming a true scientist from Sinclair Lewis's Arrowsmith

Sinclair Lewis's most widely-read novels are Main Street and Babbitt. In both of these novels his main characters were pathetic participants of narrow-minded American suburbia. Mark Schorer, the eminent Sinclair Lewis scholar, reports that Lewis wrote his editor in New York, as he was finishing Babbitt in 1921, that in his next novel he would like his central character to be heroic. That novel was to be Arrowsmith. Published in 1925, it is a long reflection on medicine, science research, and the difficult search for true understanding untainted by fame, fortune, love, humanitarian endeavors and anything else that might detract.

Arrowsmith is one of America's most profound works of fiction centered on science -- medical science in this case. Sinclair Lewis came from a family devoted to medicine. His father, grandfather, brother and uncle were all doctors. He contemplated becoming one himself. In preparing to write Arrowsmith, he spent countless hours with Paul de Kruif, an esteemed immunologist who had taught at the University of Michigan and had worked closely with such famous scientists as Jacques Loeb. Together they drafted a detailed fictional history of Martin Arrowsmith and his mentor, Max Gottlieb, who serves as the ideal of an uncompromising scientific genius. These fictional lives draw heavily on de Kruif's experience with real colleagues that Arrowsmith scholars have taken great pains to identify.

Over 75 years after Arrowsmith was published, every professional scientist can still see the sharp commentary on the challenges and thrills of scientific research. The forces that pulled the struggling young scientist Martin Arrowsmith away from quality science research are very nearly the same forces that many experience today. The novel works not just because Lewis had extraordinary ability as a novelist, but also because Lewis interviewed de Kruif so thoroughly about the life of a research scientist and was able to bring that knowledge alive in an interesting fictional account.

Max Gottlieb, Arrowsmith's mentor, is a unique character among prominent 20th century works of fiction. It is apparent that Lewis and de Kruif intended that Gottlieb embody the ideal scientist. He was a displaced German Jew from Saxony who demanded excellence and purity in science research, and who tended to denigrate people around him as hacks, including most Americans who had no patience for the "beautiful dullness of long labors." Gottlieb's implacable devotion to purity and precision led him to hate scientists who rushed unfinished work into publication more than he hated "the devil or starvation." He preached "the loyalty of dissent, the faith of being very doubtful ...." Arrowsmith fell under his spell, and worked the rest of his life, in fits and starts, to achieve the science ideal that Gottlieb exemplified.

When Arrowsmith first came to Gottlieb with a desire to work with him, Gottlieb wasted no time teaching Arrowsmith what it means to be a scientist:

> *There are two kinds of students the gods give me. One kind they dump on me like a bushel of potatoes. I do not like potatoes, and the potatoes they do not ever seem to have great affection for me, but I take them and teach them to kill patients. The other kind -- they are very few! -- they seem for some reason that is not at all clear to me to wish a liddle bit to become scientists, to work with bugs and make mistakes. Those, ah, those, I seize them, I denounce them, I teach them right away the ultimate lesson of science, which is to wait and doubt. Of the potatoes, I demand nothing; of the foolish ones like you, who think I could teach them something, I demand everything.*

Arrowsmith did get the opportunity to work with Gottlieb, and labored many long hours in order to impress Gottlieb as much as any other reason. When Arrowsmith completed some experiments on a serum, he came to conclusions at odds with the prevailing views of science. Gottlieb challenged young Arrowsmith:

> *'Young man, do you set yourself up against science?' grated Gottlieb .... 'Do you feel competent, huh, to attack the dogmas of immunology?'*
>
> *'I'm sorry, sir. I can't help what the dogma is. I only know what I observed.'*
>
> *Gottlieb beamed. 'I give you, my boy, my Episcopal blessings! That is the way! Observe what you observe and if it does violence to all the nice correct views of science -- out they go! I am very pleast, Martin. But now find out the Why, the underneath principle.'*

Gottlieb's pleasure was a jolt of adrenaline to Arrowsmith, who "trotted off blissfully, to try to find (but never to succeed in finding) the Why that made everything so." It is a sentence that accurately reflects the growing up of a scientist, who, when first experiencing success, thinks that answers to the big Why questions are only a few weeks away, but ultimately finds that progress is very slow for true understanding and progress.

Martin Arrowsmith graduates from college and ambles through several unsatisfactory positions, where he encounters the frustrations of dealing with simpletons, hucksters and materialists. He also finds nobody that really understands the way of thinking that Gottlieb had taught him. Despite the pressures to be more practical in his activities at the Rouncefield Clinic, Arrowsmith publishes his "streptolysin paper" in the Journal of Infectious Diseases. None of his colleagues read the paper or are impressed by his efforts. His spirits are lifted when he gets a letter from Gottlieb, who says that he has read the paper carefully and likes it. He tells Arrowsmith, "I feel you should be tired of trying to be a good citizen and ready to come back to work." He wants Arrowsmith to join him at the McGurk Institute in Chicago. Arrowsmith does.

When Arrowsmith arrives, Gottlieb asks him what he wants to do at the McGurk Institute. Arrowsmith responds, "Why I'd like to help you", but Gottlieb will have none of that. "You are to do your own work. What do you want to do? This is not a clinic; wit' patients going through so neat in a row!" Gottlieb explains.

Arrowsmith then tells Gottlieb what he would like to do, but Gottlieb is uninterested in the details. Nevertheless, Gottlieb uses the moment as an opportunity to teach Arrowsmith that although he does not care what he specifically does, he is expecting Arrowsmith to share his vision of what it means to be a scientist. Gottlieb delivers a long speech to Arrowsmith, which summarizes in the most plain language what he calls his "religion of science":

> *To be a scientist -- it is not just a different job, so that a man should choose between being a scientist and being an explorer or a bond-salesman or a physician or a king or a farmer. It is a tangle of ver-y obscure emotions, like mysticism, or wanting to write poetry; it makes its victim all different from the good normal man. The normal man, he does not care much what he does except that he should eat and sleep and make love. But the scientist is intensely religious -- he is so religious that he will not accept quarter-truths, because they are an insult to his faith.*
>
> *He wants that everything should be subject to inexorable laws. He is equal opposed to the capitalists who t'ink their silly money-grabbing is a system, and to liberals who t'ink man is not a fighting animal; he takes on both the American booster and the European aristocrat, and he ignores all their blithering. Ignores it! All of it! He hates the preachers who talk their fables, but he iss not too kindly to the anthropologists and historians who can only make guesses, yet they have the nerf to call themselves scientists! Oh, yes, he is a man that all nice good-natured people should naturally hate!*
>
> *He speaks no meaner of the ridiculous faith-healers and chiropractors than he does of the doctors that want to snatch our science before it is tested and rush around hoping they heal people, and spoiling all the clues with their footsteps; and worse than the men like hogs, worse than the imbeciles who have not even heard of science, he hates pseudo-scientists, guess-scientists -- like these psycho-analysts; and worse than those comic dream-scientists he hates the men that are allowed in a clean kingdom like biology but know only one text-book and how to lecture to nincompoops all so popular! He is the only real*

revolutionary, the authentic scientist, because he alone knows how liddle he knows.

... But once again always remember that not all the men who work at science are scientists. So few! The rest -- secretaries, press-agents, camp-followers! To be a scientist is like being a Goethe: it is born in you. Sometimes I t'ink you have a liddle of it born in you. If you haf, there is only one t'ing -- no, there is two t'ings you must do: work twice as hard as you can, and keep people from using you. I will try to protect you from Success. It is all I can do. So I should wish, Martin, that you will be very happy here. May Koch bless you!"

Five minutes later, Arrowsmith finds himself alone in the laboratory, enraptured by the possibilities of his new position, and prays the "prayer of the scientist" that Gottlieb would have smiled upon if he had heard it:

God give me unclouded eyes and freedom from haste. God give me a quiet and relentless anger against all pretence and all pretentious work and all work left slack and unfinished. God give me a restlessness whereby I may neither sleep nor accept praise till my observed results equal my calculated results or in pious glee I discover and assault my error. God give me strength not to trust to God!

Arrowsmith experiences both success and tragedy as a result of his calling as a pure scientist. He is committed to Gottlieb's ideals to the very end -- it seems he has no choice. He also knows that there is little chance that he will make significant progress in revealing new science knowledge, but he finds a kind of solace in the attempt and the thrill of just maybe being lucky and contributing to something big. He was sustained by the encouragement Gottlieb gave him, "So many men, Martin, are good and neighborly; so few have added to knowledge. You have the chance!" It is a story every person who has (or had) aspirations of being a "pure scientist" can appreciate. It is a novel of deep reflection about the scientific pursuit that enlightens as much as it entertains.

(2011)

Professor von Jolly's 1878 prediction of the end of theoretical physics, as reported by Max Planck

Abstract

It is provided here the original German and an English translation of a passage from a 1924 essay by Max Planck that reports a prophecy of the end of theoretical physics expressed to him by one of his esteemed physics professors, Philipp von Jolly, while Planck was attending the University of Munich as a student in 1878. The decades to come, which saw the revolutions of relativity and quantum mechanics, proved the prognostication to be misguided.

Introduction

Periodically there are unimaginative voices that declare we are in a very unique and special time of history. A time when fundamental science is over and all that is left is carrying out more precise measurements and applying already understood and known laws toward applied engineering problems. Invariably such pronouncements of the barren future of science turn out to be more of a reflection on the pronouncer's mindset than on the actual prospects of future science progress.

Anyone who declared physics over in the 19th century was quite mistaken. What we know now would be mostly unrecognizable to the Victorians. General Relativity, Inflationary Cosmology, Nuclei, Atomic theory, Quantum Mechanics, Particle Physics, Quarks, Gluons, and the Higgs boson are just a few of the terms that evoke revolutions in our understanding of the natural world. All would be met with blank stares by even the best physicist equipped with only 19th century understanding.

In the present era we know about these revolutions in physics that took place over the last century, but some of the scientists those many years ago were not able to discern progress on the day to day level. They did not recognize that pushing hard to expand current understanding, whose benefit may go at an unrecognized glacial pace, will one day pay off. Measurements of progress can not be made easily in the course of weeks or years. The arc of truly meaningful discoveries is often only seen from a perspective of decades or more.

It is helpful to be reminded periodically of confident wrong predictions in order to inoculate ourselves against similar wrong thinking today. And the task of doing that was taken up by Max Planck in 1924, when he gave an address to the University of Munich entitled "Von Relativen zum Absoluten" (From the Relative to the Absolute). The passage below speaks for itself but let us say a few short words about Max Planck for those who are not familiar.

Max Planck was born in 1858 in Kiel and was educated at Friedrich Wilhelms University (FWU) in Berlin, where he was taught by several luminaries of physics and mathematics, including Helmholtz, Weierstrass and Kirchhoff. After defending his habilitation thesis in 1880 he became Privatdozent in Munich and ultimately made his way back to Berlin where he became a full professor in 1892 at the age of 34. He retired from FWU Berlin in 1926. He is most known today for his work in 1900 explaining black body radiation. His quantization ideas heralded the beginning of the quantum mechanics era which brought revolutions of basic science insight and applied science applications to the world. He also was a philosophical thinker and his ideas and approach to science were influential in the early 20th century.

In the passage below Planck refers to Prof. Philipp von Jolly (1809-1884). Unfortunately for von Jolly, he is most known today for his comments to Planck in 1878, near the end of von Jolly's career, regarding the end of physics. However, von Jolly's career was also illustrious, having made important contributions to the fields of gravitation and osmosis science. The esteem in which he was held among those in the scholarly community is evidenced by his knighthood in 1854. As we see, even knighted, respected scholars can be wrong, especially when prophesying that the future (no new science) will be fundamentally different than the past (continual new science breakthroughs).

In the next two sections the original German version and English translation of the quote by Planck is presented. As mentioned above, this comes from his talk "Vom Relativen zum Absoluten" in 1924 which is reprinted on pp. 128-146 of Planck (1933).

Passage in the Original German

"Als ich meine physikalischen Studien begann und bei meinem ehrwürdigen Lehrer Philipp v. Jolly wegen der Bedingungen und Aussichten meines Studiums mir Rat erholte, schilderte mir dieser die Physik als eine hochentwickelte, nahezu voll ausgereifte Wissenschaft, die nunmehr, nachdem ihr durch die Entdeckung des Prinzips der Erhaltung der Energie gewissermaß en die Krone aufgesetzt sei, wohl bald ihre endgültige stabile Form angenommen haben würde. Wohl gäbe es vielleicht in einem oder dem anderen Winkel noch ein Stäubchen oder ein Bläschen zu prüfen und einzuordnen, aber das System als Ganzes stehe ziemlich gesichert da, und die theoretische Physik nähere sich merklich demjenigen Grade der Vollendung, wie ihn etwa die Geometrie schon seit Jahrhunderten besitze. Das war vor fünfzig Jahren die Anschauung eines auf der Höhe der Zeit stehenden Physikers."

English Translation of the Passage

"As I began my university studies I asked my venerable teacher Philipp von Jolly for advice regarding the conditions and prospects of my chosen field of study. He described physics to me as a highly developed, nearly fully matured science, that through the crowning achievement of the discovery of the principle of conservation of energy it will arguably soon take its final stable form. It may yet keep going in one corner or another, scrutinizing or putting in order a jot here and a tittle there, but the system as a whole is secured, and theoretical physics is noticeably approaching its completion to the same degree as geometry did centuries ago. That was the view fifty years ago of a respected physicist at the time."

Acknowledgments: I wish to thank G. Knodel and T. Rindler-Daller for helpful discussions.

Reference

Planck, Max (1933). *Wege zur Physikalischen Erkenntnis: Reden und Vorträge*. Leipzig: Verlag von S. Hirzel.

(2016)

Reprehensible Behavior in a Large Population Theorem

Reprehensible Behavior in a Large Population Theorem :

Consider any imaginable reprehensible behavior(s) X. As the population N tends toward the large-N limit, there exist people doing X. In the limit that the population N goes to infinity there are an infinite number of people doing X.

RB Sub-Population Corollary :

Any sub-population N' of N, which is a finite non-zero fraction of N, satisfies the above theorem.

Selective Propaganda Proposition :

Since X will happen in a large population, a news agency or news aggregate or social media activist can paint a sub-population N' as degenerates doing X at an arbitrarily high rate by running stories of N' only doing X.

Theorem Generalizations :

The RBLP theorem could just as easily be valid when replacing "Reprehensible" with "Impressive" and everything carries forward. You can make a sub-population look like supermen and superwomen by only running stories of them demonstrating some amazing, impressive behavior.

Indeed, X could be any characteristic and the theorems, corollary and proposition would be just as valid. Understanding these are the key to manipulation of an audience.

(2016)

Breakdown of the 1994 Agreed Framework between the United States and North Korea

There is much talk about the failed 1994 Agreed Framework [1] between the United States and North Korea, and what lessons it may have for our attempts to reign in Iran's nuclear weapons ambitions. It may be useful to review a somewhat technical description of what the Agreed Framework tried to accomplish, and how North Korea built nuclear bombs anyway.

Let us start many decades ago. Since the 1960s North Korea has had nuclear fission reactors at its Yongbyon facility. Its main reactor is a 5 MWe gas-graphite Magnox reactor, which fissions uranium to produce electricity for normal power consumption, and, can create plutonium as a byproduct for nuclear weapons.

The existence of a nuclear reactor on North Korean soil might sound alarming on its own, but it was thought in the earlier days of nuclear power that the type of reactors that North Korea had would not be useful for bomb making. The uranium fuel needed for reactor operation has very little fissile U-235, certainly less than needed for a nuclear bomb. Reactor-grade uranium fuel is typically less than 5% U-235, whereas the nuclear bomb safe isotope U-238 accounts for over 95%. North Korea's gas-graphite reactor takes natural uranium as fuel with less than 1% U-235. To enrich the fuel further to the much higher concentrations of U-235 needed to make a bomb requires highly technical centrifuging techniques that separate the U-235 isotope from the U-238 isotope. This is technology and know-how that North Korea on its own did not possess, and the danger of it possessing it in the future was thought to be low, and anyway it would be found out if they tried.

An easier path to the bomb for North Korea, on the other hand, was understood to be through plutonium. Bomb-grade plutonium can be extracted from uranium fuel that burns up in normal reactor operation. The reprocessing of the used fuel to extract plutonium was thought to be the primary proliferation risk and concern. North Korea was suspected of working toward just that aim in the late 1980s and early 1990s. Confrontation between North Korea and the United States over these suspicions led to the Agreed Framework in 1994, where North Korea agreed, among other things, to stop the reprocessing of nuclear fuel for the purposes of extracting plutonium for bombs, and to grant full inspection rights to the IAEA of North Korean nuclear sites. In exchange the U.S. agreed to provide oil and much needed humanitarian aid, to give North Korea security promises (i.e., the U.S. will not attack them), and to facilitate construction of a new light-water reactor that has much less proliferation concerns.

The 1994 Agreed Framework was voided by the Americans when it was discovered in 2002 that North Korea had begun a uranium enrichment program [2]. Although uranium enrichment is not explicitly proscribed in the Agreed Framework, the U.S. interpreted this activity as a violation. North Korea, on the other hand, continued to maintain that enrichment was not in direct violation of the Agreed Framework, and that anyway the United States was not living up to its end (e.g., providing a light-water nuclear reactor in a timely fashion) so if anybody is to be charged with violating the Agreed Framework first, it should be the United States.

Regarding whether uranium enrichment was in direct violation, the Agreed Framework required that North Korea remain party to the Nuclear Non-Proliferation Treaty [3], which however does not forbid uranium enrichment. The closest direct statement in the Agreed Framework against uranium enrichment is the statement that "The DPRK will consistently take steps to implement the North-South Joint Declaration on the Denuclearization of the Korean Peninsula" [4]. That document clearly disallows uranium enrichment: "Under the Joint Declaration, the Democratic People's Republic of Korea (DPRK) and the Republic of Korea (ROK) agree not to test, manufacture, produce, receive, possess, store, deploy, or use nuclear weapons; to use nuclear energy solely for peaceful purposes; and not to possess facilities for nuclear reprocessing and uranium enrichment." However, technically speaking, the Agreed Framework does not say that North Korea must abide by all the terms of the Joint Declaration, but rather "take steps." One could interpret this as a failure of U.S. diplomats to cover the bases; nevertheless, few would disagree that it was in violation of the spirit of the Agreed Framework, and U.S. suspension of its obligations under it, and its declaration that North Korea was in violation of it, was a justified response.

North Korea quickly made their own counter-response by withdrawing from the Nuclear Non-Proliferation Treating, expelling IAEA inspectors and announcing the restart of their reactors and plutonium reprocessing. Several years later North Korea conducted two nuclear bomb tests in 2006 and 2009. These bombs were made of plutonium extracted from their spent nuclear reprocessing work. Further tests have ensued and the diplomatic standoff is still critical today.

Additional technical details of reprocessing and fuel composition of reactors and bombs relevant for the North Korean nuclear weapons program can be found at [5].

References

[1] *Agree Framework Between The United States of America and the Democratic People's Republic of Korea*. Geneva, 21 October 1994. http://2001-2009.state.gov/t/ac/rls/or/2004/31009.htm

[2] "N Korea 'admits nuclear programme'". BBC News (17 October 2002) http://news.bbc.co.uk/2/hi/asia-pacific/2335231.stm

[3] *Treaty on the Non-Proliferation of Nuclear Weapons (NPT)*. Signed July 1, 1968. Ratified by U.S. Senate March 13, 1969, entered into force March 5, 1970. http://www.state.gov/t/isn/trty/16281.htm

[4] *Join Declaration of South and North Korea on the Denuclearization of the Korean Peninsula*. Signed 20 January 1992, entered into force 19 February 1992. http://www.nti.org/media/pdfs/aptkoreanuc.pdf

[5] J.D. Wells. "Science background to North Korea's nuclear bomb program." July 14, 2011. http://www-personal.umich.edu/~jwells/publications/jdw110714.pdf

(2016)

Ginzburg's regret at not being the first to discover the BCS theory of superconductivity

The theory of superconductivity has gone through four significant phases of understanding. The first phase was Londons theory of superconductivity (1933), which was a successful phenomenological theory in some ways (e.g., explained Meissner effect) but unsuccessful in other ways (e.g., failure to understand end of superconducting state at high currents).

The second phase was the Ginzburg-Landau theory (1950) which applied Landau's theory of phase transitions to superconductivity with great success. In particular it gave descriptive understanding of coherence length, type I and II superconductors, and quantization of magnetic flux and vortices.

The third phase was the discovery of BCS theory (1956), which gives a perturbative microscopic understanding of the Ginzburg-Landau theory. And the fourth phase, which we are still in, is the discovery of high-Tc superconductors, for which we still do not have a complete understanding.

The history of superconductivity has many lessons to learn, both in the principles of physics but also in the culture of scientific discoveries and missed opportunities.

In the category of missed opportunities, Ginzburg points out in his Nobel Prize lecture of 2003 that he and Landau missed an insight that perhaps should have been seen, and which perhaps could have led them to the BCS theory before Bardeen, Cooper and Schrieffer.

The theory of superconductivity that they developed was based on the Ginzurg-Landau potential

$$V_{GL}(\Psi) = \alpha|\Psi|^2 + \beta|\Psi|^4$$

where ▯ is the order parameter for superconducting charge carriers. When an electromagnetic field is applied the free-energy requires the addition of the vector potential added to the gradient term:

$$\left(-i\hbar\nabla - \frac{e^*}{c}A\right)\Psi$$

When you construct the superconducting current you find

$$\boldsymbol{j}_s = \frac{ie^*\hbar}{2m^*}(\Psi^*\nabla\Psi - \Psi\nabla\Psi^*) - \frac{(e^*)^2}{m^*c}|\Psi|^2\boldsymbol{A}$$

The observables of the theory, such as the penetration depth and the critical magnetic field, depend on these "phenomenological parameters" $\boldsymbol{m^*}$ and $\boldsymbol{e^*}$. They are phenomenological parameters because the Ginzburg-Landau theory was a phenomenological theory that had no first-principles derivation.

Now, it is tempting to say that *m** and *e** should be connected to the electron mass and charge. After all, what else is there in the superconductor that could carry the superconducting current! However, Ginzburg and Landau recognized immediately that *m** could deviate far from the electron mass just as there are "effective masses" in the theory of metals, and it would depend on temperature and other properties. However, as Ginzburg reports, "Landau did not see why*e** should be different than *e*, and in our paper it is written as some compromise that 'there are no grounds to believe that the charge *e** is different from the electron charge'" (Ginzburg 2003).

The trouble was that Ginzburg later compared theory with experimental and found that $e^*=(2\text{-}3)e$ was required. The naive view that *e** had to be equal to *e* just wasn't fitting the data. Landau's response was to argue that, like the effective mass, "the effective charge may and, generally speaking, will depend on the coordinates, because the parameters that characterize the semiconductor are functions of the temperature, the pressure, and the composition, which in turn depend on the coordinates **r**" (Ginzburg 2003).

When BCS was discovered a few years later it became obvious that *e** was near 2*e* because of the special Cooper pairing of electrons that take place inside a superconductor to form a superconducting bosonic state. You can almost feel the sharp regret in Ginzburg's tone when he talks about it in his 2003 speech so many years later:

"Landau was right in the sense that the charge *e** should be universal and I was right in that it is not equal to *e*. However, the seemingly simple idea that both requirements are compatible and $e^*=2e$ occurred to none of us. After the event one may be ashamed of this blindness, but this is by no means a rare occasion in science, and it is not that I am ashamed of this blindness, but I am rather disappointed that it did take place" (Ginzburg 2003).

Ginzburg's contributions to science and the theory of superconductivity were extraordinary and worthy of the Nobel Prize, and they are still studied to this day. Yet, we can also find value in seeing that he missed opportunities. I suspect that we all have many opportunities for keen, and maybe even dramatic, insight swirling around us, and we can only hope that we concentrate hard enough and work hard enough to grasp at least one or two of them before they float away.

Reference

Vitaly L. Ginzburg. "On Superconductivity and Superfluidity." Nobel Lecture, December 8, 2003.

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“Please, sir, I want some more citations”

[Recently discovered letter from Oliver Twist sent to James Clerk Maxwell 150 years ago today. Little known that Twist got bored in the country and studied to become a mathematical physicist.]

March 27, 1866

Dear Prof. James Clerk Maxwell,

I have read with great pleasure your preprint on the theory of Electromagnetism that you kindly sent to our Mathematics Library in Coventry. I find that it has answered several important and pressing questions posed in the literature and opened up new questions that were not thought of before. Congratulations on an excellent paper.

However, I did want to draw your attention to some previous work of mine that has some bearing on your work. In section 3 of your paper you utilized the result that 3*7=21. You will find that I was the first to draw attention to this result in a paper written two years earlier entitled, “Low Multiplicities of Seven”. You will notice that eq. 79 of that paper has 3*7=21 explicitly written. You will also find that the result was anticipated in an earlier publication by me and my collaborator, Prof. Art Dodge (Provost at Adelaide College), entitled “Multiplicities of Three: a Comprehensive Survey”, where we explicitly wrote down that 6*3=18 in eq. 92 and then elsewhere in the paper noted that 18+3=21 (see eq. 173).

We hope that you will kindly take a look at these earlier papers and cite them in the appropriate places.

Sincerely, Dr. Oliver Twist

(2016)

Traits of extraordinary achievers

Recently I had dinner with young researchers in high energy theory who asked me what in my view were the key factors that led to success in scientific research. I told them that "extreme talent" combined with "extreme dedication" usually wins the day. People focus on the "freakishly smart" aspect of the highest achievers, but the commitment level, the dedication and focus, needed to get to the very top is just as "freakish" and perhaps more rare. The very best are brilliant and always "on."

I also told them that in the past extreme talent with high (but not necessarily extreme) dedication was possible if you wanted to land a faculty position at a research university, for example, but the competition is so fierce now that I was not sure that was possible today. However, it was also my impression that today you can have high (but not extreme) talent with extreme dedication and make it. But having both always makes it easier.

So, over time, extreme talent has lost to extreme dedication for the number one trait that you just cannot go without. If I were forced to speculate on why I'd say it might have to do with the rise of experiments with many hundreds and even thousands of collaborators, where extreme talent and brilliance does not have to be present in *everyone*, but extreme dedication does (or "conscientiousness" as we will talk about below). Furthermore the increasingly high premium on constant and visible productivity signs (publications, talks, etc.) contribute to the shift for both experimentalists and theorists. But that is speculation and it would be interesting to see a study ask and answer that question.

I was also reminded of an undergraduate professor of mine at Brigham Young University who spoke about the traits of extreme achieving students he had seen over the years. And he said the biggest was tenacity. The very best of the best do not rest until they know everything there is to know about what is being said, and they have the mental ability to absorb it and sort it out, often on their own. They will not rest until every factor of 2 is understood, until every minus sign is certified, and until every conceptual input of the problem is precisely defined and understood. "They don't let you get away with anything!" he said, like he had been injured badly by some. He claimed that he could tell in a student's sophomore classes with high probability if they will succeed grandly or not. He could not tell if a student would be good, mediocre or bad, but he could tell that some would be great.

After the discussion with the young researchers I ran across a New York Times article (Hart & Chabris 2016b) on exactly this subject. What are the traits of extreme achievers who experience great success in life? Since it was right on my mind I have spend some time reading the corresponding social science literature and sorting out the claims (as best as a physicist can do over a short time) to see how they match with the comments I gave the young researchers and with comments by my undergraduate professor on the topic.

Social Science Literature

Hart and Chabris (2016b) opined on their study regarding traits that are most probable predictors of success, where success can be defined as those who “attain exceptional achievement”, defined to be “higher socioeconomic status”, which translates to wealth and status in the business sector and high distinction in intellectual endeavors.

Hart and Chabris, who published their work in a peer-reviewed journal (Hart & Chabis 2016), were drawn to the question when Chua and Rubenfeld (2014) put forward a theory in their best-selling book of 2014 that “attempted to explain why certain minority groups in the United States, such as Jews, Mormons and Asian-Americans, seem associated with extraordinary success (i.e., higher socioeconomic status) relative to other groups.” (Hart & Chablis 2016).

Chua and Rubenfeld Theory

The Chua and Rubenfeld “Triple Package” theory of extraordinary achievers, which Hart and Chabris subjected to social science methodology and data, says that these high achieving groups possess three common characteristics:

1) a “sense of group superiority” (ethnocentricism or intergroup bias),

2) “personal insecurity” (e.g., due to vulnerability in society, or low self-esteem, or some other reason), and

3) highly developed “impulse control” (scoring very high on “Big five conscientiousness” to be discussed below)

Chua and Rubenfeld suggested that 1 and 2 lead to “drive” and 1 and 3 lead to “grit”, and the combination of “drive” and “grit” from the presence of all three traits leads to extraordinary success.

Hart and Chabris Findings regarding Chua and Rubenfeld’s Theory

Hart and Chabris studied the question in controlled research environment. The main resulting message from their study is that the Chua and Rubenfeld theory is not a rigorously valid theory. The abstract of the paper is informative which I quote below:

“What individual factors predict success? We tested Chua and Rubenfeld's (2014) widely publicized “Triple Package” hypothesis that a tendency toward impulse control, personal insecurity, and a belief in the superiority of one's cultural or ethnic group combine to increase the odds that individuals will attain exceptional achievement. Consistent with previous research, we found in two sizable samples (combined N = 1258) that parents' level of education and individuals' own cognitive ability robustly predicted a composite measure of success that included income, education, and awards. Other factors such as impulse control and emotional stability also appeared to be salutary. But despite measuring personal insecurity in four different ways and measuring success in three different ways, we did not find support for any plausible version of Chua and Rubenfeld's proposed synergistic trinity of success-engendering personality traits" (Hart & Chabris 2016).

However, the abstract seems to be worded much stronger than is warranted from the body of the paper. For example, the abstract seems to imply that the "Triple Package" theory does not correlate with success, but in fact all of those traits do correlate with success, which they do not necessarily disagree with in the body of the paper.

Here's one example regarding "insecurity". Social scientists have many ways to define that, but one way is "contingent self-worth". This is when "self-esteem … is predicated on external sources, and hence presumably more fragile" (Hart & Chabris 2016). If that is how insecurity is defined, which is not inconsistent with Chua and Rubenfeld, then "the TP hypothesis fares somewhat better: participants whose self-esteem depended on their appearance, others' opinions, and on doing well in competitive contexts scored higher on the composite success measure, albeit only if they were also relatively high in ethnocentrism" (Hart & Chabris 2016). But "contingent self-worth" is plausibly consistent with Chua and Rubenfeld's "insecurity" criterion, and if so their claim that it goes with ethnocentrism is consistent with data, according to Hart and Chabris.

It is probably fair to say that Chua and Rubenfeld's Triple Package of traits is well correlated with success but may very well not be the most efficient and correlated statements one can make. There are different independent axes that are more important than their "Triple Package" despite the fact that those axes can overlap.

Hart and Chabris Theory of Success

Hart and Chabris have their own ideas on what are the most important drivers for success. Surveying the literature and their own studies they put forward their theory : "The totality of the evidence suggests that the mostly likely elements of a triple package would be intelligence, conscientiousness, and economic advantage: the same factors that would benefit anyone, regardless of ethnicity." (Hart & Chabris 2016).

In a New York Times article (Chabris & Hart 2016b) the authors restate their theory of what are the key factors of extraordinary achievement : "our studies affirmed that a person's intelligence and socioeconomic background were the most powerful factors in explaining his or her success."

They also reiterate that conscientiousness is also key : “Long before ‘The Triple Package,’ [of Chua and Rubenfeld] researchers determined that the personality trait of conscientiousness, which encompasses the triple package’s impulse control component, was an important predictor of success — but that a person’s intelligence and socioeconomic background were equally or even more important” (Chabris and Hart 2016b).

Synthesis of the literature

Reading the ones listed above plus forays into the other articles cited suggest that there are three key correlations for extraordinary achievement : 1) high intelligence, 2) high socioeconomic background, and 3) high conscientiousness, in that order, but all three vital. And there are many other traits that are just not that important as key source indicators. In other words, even though conscientiousness may be third on the list, it is “key” and beat out many other extraneous characteristics.

Conscientiousness in the social science literature is very precisely defined as one of the “Big Five” personality traits. The “Big Five” are sort of basis vectors in personality space, and the basis traits are :

- openness to experience
- conscientiousness
- extraversion
- agreeableness
- neuroticism

The Big Five Traits are sometimes called OCEAN or CANOE, based on the first letter of each trait, and you can find yourself very far to the left (e.g., definitely not possessing X at all) or very far to the right (e.g., definitely possessing trait X in full). The claims are that none of the traits matter so much compared to conscientiousness when it comes to extraordinary achievement.

But what is “conscientiousness”? Here are the characteristics of conscientiousness as listed by three different sources.

“Lexical facets” (Saucier & Ostendorf 1999) :
Orderliness, Industriousness, Reliability, Decisiveness

“NEO-PI-R facets” (Costa & McCrae 1992) :
Order, Achievement Striving, Dutifulness, Self-Discipline, Competence, Deliberation

“CPI-Big Five facets” (Soto & John 2008) :
Orderliness, Industriousness, Self-Discipline

Another description of conscientiousness helps put the trait in a fuller context:

“Conscientiousness (Efficient/Organized vs. Easygoing/Careless): This is a feature that expresses self-discipline and determination and desire for achievement. It expresses an intention to behave in a planned matter, goal-directed and thinking before acting. Such people follow norms and rules; they are always on time, study hard, and give their best to the job. They are not impulsive and show high values of thoughtfulness (John et al. 2008)” (Richter & Dumke 2015).

So, order and self-discipline is a key factor for extraordinary achievers.

Discussion on intelligence

Regarding intelligence, which is often listed as the leading indicator of success, it is often very tricky to talk about it, since one normally does not have much control over it, except the ability to damage it (through drug and alcohol abuse, etc.). Subconsciously perhaps that is why I use instead the word “talent” since it isn’t such an aggressive word, and implies the possibility that there is something you can do about it. However, recognizing that intelligence is a component of an individual’s future success is good for society and institutions for several reasons that should be considered. For example, for society, it is well known that early childhood education and nutrition is key to enhancing intelligence, or at least not diminishing intellectual capacity. There are important public policy priorities that can be affected by understanding the key role of intelligence.

Discussion on socioeconomic status

Regarding the socioeconomic indicator of success. This did not occur to me within the realm of scientific achievement. I have read before that your income at age 40 is more correlated with your parents’ income at age 40 than anything else, including educational level. So in the business world I am more apt to agree that this is important, for reasons that I admit I do not fully understand. In academia, however, I naturally resist thinking that this is as important as the other two criteria (intelligence and conscientiousness). I can imagine that it is correlated with many good things, such as good nutrition, good education at school, parental investment, etc., and so it makes sense that it is very likely to be a positive benefit, but the implication in the studies is that it is more than a nice nudge, it is quite important, and it is a needed addition to the mix of success “traits” in addition the other two. I don’t understand it, and I didn’t think of it, since I am not privy to my student’s socioeconomic background, but it is interesting.

The other reason why I question socioeconomic status as a strong independent factor is an analogy with the weather. Imagine somebody said that the three most important indicators of the temperature reading at some location on January 23rd are 1) its latitude, 2) its altitude, and 3) the temperature reading on January 22nd. Well, sure, the temperature on January 22nd (socioeconomic status of the parents, previous generation) is a very good indicator of the temperature on January 23rd (socioeconomic status/success of the next generation), but the real reason is the latitude and altitude that is applicable to both (conscientiousness and intelligence). Obviously the analogy is not perfect, in part for the reasons stated in the previous paragraph, but I remain curious to know more why it is considered a strong independent variable.

It does remind me from when I was filling out applications to graduate school. Yale asked me to fill in a detailed report of my parents earnings and jobs and positions, despite the fact that basically no Physics PhD student at Yale (or Michigan or any other good place) needs to pay a dime of tuition (all comes through teaching or research assistantships or scholarships). I was appalled and said that that had nothing to do with whether somebody should accept me to a physics PhD program and refused to fill it out and withdrew my application. (Alas, the brashness and idealism of youth…) I was from a privileged background but I did not think that should be used for my advantage. But maybe Yale was on to something and they just wanted to use it as a predictor? I still don't like the thought of it though, and I'm going to guess that Yale doesn't do it anymore, even though I haven't checked.

Discussion on Conscientiousness

Regarding conscientiousness, in the "lexical facets" of "conscientiousness" stated above, the term "reliability" is included. Some might say this is decidedly not the trait of some of our most successful researchers in the field. They may not care to show up for faculty meetings, or they teach poorly, or basically ignore everything in their lives except their research — laser focus on that aspect of their jobs, and letting go everything else. And when it comes to service assignments in the department, perhaps they are not so reliable.

But anecdotally I can think of no cases like this of an "unreliable" extraordinary achiever without the individual being completely off the charts in intelligence and research dedication, and without them coming from excellent socioeconomic backgrounds. Extreme outliers in both intelligence and dedication may be immune, therefore, from personality trait requirements, it might be said, whereas most others need strong conscientiousness to be an extraordinary achiever. However, it should be said that there are extreme outliers of intelligence who are reliable professionally, so unreliability is not a definitive marker for extreme intelligence (let's not tempt colleagues to lay down on the job!). It's just that it appears some can *survive* high unreliability if their intelligence and dedication is extreme enough.

Lastly, it strikes me that conscientiousness is the most important trait since it is the one trait that an individual has the most control over when attempting to become extraordinarily successful. Its position as third on the list may be true for outsiders predicting whether or not an individual will be successful, but it surely must come in first place among areas to work on for those who want to climb the latter of success. I see how outsized this trait is in success in academia, and I am not surprised to see that the social science literature finds it to be outsized compared to other personality traits.

Summary

If you remember one sentence from this discussion, and you want to know what you can do to be an extraordinary achiever, it is this : Your extraordinary success will require high intelligence (let's hope you have it) and high conscientiousness (let's hope you get it).

References

Chua, A., Rubenfeld, J. (2014). The Triple Package: How Three Unlikely Traits Explain the Rise and Fall of Cultural Groups in America. Penguin Books.

Costa, P.T., jr, McCrae, R.R. (1992). NEO PI-R professoinal manual. Odess, FL: Psychological Assessment Resources.

Hart, J., Chabris, C.F. (2016). Does the 'Triple Package' of traits predict success? Journal of Personality and Individual Differences, vol. 94, pp. 216-222.

Hart, J., Chabris, C.F. (2016b). How Not to Explain Success. New York Times, April 8, 2016.

John, O.P., Robins, R.W., and Pervin, L.A. (2008). Handbook of Personality: Theory and Research. New York : Guilford Press.

Richter, K., Dumke, R.R. (2015). Modeling, Evaluating, and Predicting IT Human Resources Performance. New York: CRC Press.

Saucier, G., Ostendorft, F. (1999). Hierarchical subcomponents of the Big Five personality factors : A cross-language replication. J. of Personality and Social Psychology, 76, pp. 613-627.

Soto, C.J., John, O.P. (2008). Measuring Big Five domains and 16 facets using the California Psychological Inventory. unpublished manuscript.

(2016)