Serendipity, talent and innovation

Andrea Rapisarda

Dipartimento di Fisica e Astronomia “Ettore Majorana” and INFN
Università di Catania, Italy
Complexity Science Hub Vienna, Austria
I will present the results of this paper (published in 2018) on the role of *talent* and *luck* in getting success in life and science.

*Results are related to science funding, but also on equity and inclusion.*
Motivations and introduction

1. *Is chance important* in scientific discoveries?

2. *What is the role of luck / randomness* in our life?

3. *Are the most successful people also the most talented ones?*

4. *What can we do to improve the efficiency of science and society?*
In Science there is a well-known phenomenon called

“Serendipity”

i.e. discovery *by chance*

Of course one must be a *smart and talented scientist* to recognize and exploit a lucky opportunity!

* The Oxford English Dictionary defines it, as “the faculty of making happy and unexpected discoveries by accident,”
Serendipity, i.e. discovery by chance: a few examples

In 1928 Alexander Fleming discovered Penicillin by chance … because he forgot to close a window of his lab before going on vacation: during his absence one of his staphylococcus culture plates was contaminated by a Penicillium mold spore that weakened and killed the bacteria on the Petri dish.

In 1945 he got the Nobel prize in Medicine for this discovery together with Chain and Florey.
Actually Alexander Fleming was lucky twice… or better someone before him was not so lucky …

In fact 35 years before Fleming discovery, the young Italian doctor Vincenzo Tiberio discovered also Penicillin by chance …

But Tiberio was a young doctor living in Naples. His research in the faculty aroused little interest and only in 1895, after graduation, he published his research "On the extracts of some molds" on the Italian journal “Annali di Igiene sperimentale” …. Nobody paid attention to Tiberio’s paper and he was soon forgotten!
In 1964, while working at a new type of antenna, the Horn Antenna, at the Bell’s Labs, Arno Penzias and Robert Wilson discovered by chance the cosmic microwave background radiation that permeates the universe after the Big Bang.

They got the Nobel Prize for Physics in 1978.
Serendipity, is also related to the difficulties in predicting the impact and the applications of an idea, of an invention or of a discovery

In 1989, while he was working at Cern, Tim Bernes-Lee invented the WWW protocol for linking documents and exchanging data more easily among Cern scientists all over the world.

No one could imagine at that time that, by chance, it would have become so popular among common people: today almost everyone use it for everything!

He got the A.M. Turing Award in 2016
Chance is important also for publishing your best paper: your top article can occur at any time, even at the end of your career!

(A) Publication record of three Nobel laureates in physics. The horizontal axis indicates the number of years after a laureate’s first publication, each circle corresponds to a research paper. The height of the circle represents the paper’s impact, quantified by C10, the number of citations after 10 years. The highest-impact paper of a laureate is denoted with an orange circle.

(B) Histogram of the occurrence of the highest-impact paper in a scientist’s sequence of publications, calculated for 10,000 scientists. The flatness of the histogram indicates that the highest-impact work can be, with the same probability, anywhere in the sequence of papers published by a scientist.

see Fortunato et al., Science 359, 1007 (2018)
So luck/randomness/chance is important, but…

➤ Is it possible to be successful without luck or talent?

➤ Is it easy to recognize talent?

➤ Are the most successful/famous people also the most talented ones?
J.K. ROWLING

She is the famous author of the Henry Potter saga and according to Forbes among the richest persons in UK. Her books have won multiple awards, and sold more than 400 million copies.

After her divorce, she began a teacher training course in 1995 in Edinburg and she mainly lived on state benefits. She wrote in many cafés, wherever she could get her small daughter Jessica to fall asleep.

In 1995 she finished her manuscript *Harry Potter and the Philosopher's Stone*. The book was submitted to twelve publishing houses, all of which rejected the manuscript!!

In 1996 the book was finally accepted by editor Barry Cunningham from Bloomsbury, a publishing house in London.

The decision to publish Rowling's book owes much to Alice Newton, the eight-year-old daughter of Bloomsbury's chairman, who was given the first chapter to review by her father and immediately demanded the next.

In 2017 she was named the most highly paid author in the world with earnings of £72 million ($95 million) a year by Forbes magazine.
After this huge success, in 2013 she published another book, “the Cuckoo’s calling”, with a pseudonym.

The book didn’t sell until she revealed to be the real author and then it was a success!
HOW GOOD ARE WE IN RECOGNIZING TALENT?

This is an interesting experiment which shows how much the environment influences our judgements.

In the 2007 experiment by the Washington Post, premier violinist and Grammy-winning musician, Joshua Bell, using his violin worth $3.5 million, played six of the most intricate pieces ever written for violin in the Washington D.C. metro station. Two days prior he had sold out a theater in Boston where a seat on average cost $100. However, in the 45 minutes Bell played his violin, one thousand people came within close proximity of him with only seven stopping to listen.
Names are important

In a New York University study, researchers found that people with easier-to-pronounce names often have higher-status positions at work. One of the psychologists, Adam Alter, explains to Wired, "When we can process a piece of information more easily, when it's easier to comprehend, we come to like it more." In a further study, Alter also found that companies with simpler names and ticker symbols tended to perform better in the stock market.

If your name is easy to pronounce, people will favour you more
Names are important

What’s in a Surname? The Effects of Surname Initials on Academic Success

Liran Einav and Leeat Yariv

There is abundant research identifying external characteristics (race, gender, adolescent height) that affect labor market outcomes; for recent contributions, see Bertrand and Mullinachan (2004) and Perico, Postlewaite and Silverman (2004). In this paper, we focus on the effects of surname initials on professional outcomes in the academic labor market for economists.

We begin our analysis with data on faculty in all top 35 U.S. economics

Cumulative Distributions of Surname Initials in Economics by Tenure Status

Sample: All faculty in top 5 econ

Sample: All faculty in top 10 econ

If your surname starts with the first letters of the alphabet, it is more likely to get a tenured position
Luck / randomness / chance is important, also in our every day life

a car accident, a disease or a heritage

can occur to everyone in any moment

changing our life completely!
Random factors *(bad luck)* in cellular replications can cause a cancer even if one follows the best rules to avoid it.

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**RESEARCH**


**REPORT**

**CANCER ETIOLOGY**

**Stem cell divisions, somatic mutations, cancer etiology, and cancer prevention**

Cristian Tomasetti,1,2* In Ta,3 Bert Vogelstein3*

Cancers are caused by mutations that may be inherited, induced by environmental factors, or result from DNA replication errors (R). We studied the relationship between the number of normal stem cell divisions and the risk of 17 cancer types in 69 countries throughout the world. The data revealed a strong correlation (median = 0.80) between cancer incidence and normal stem cell divisions in all countries, regardless of their environment. The major role of R mutations in cancer etiology was supported by an independent approach, based solely on cancer genome sequencing and epidemiological data, which suggested that R mutations are responsible for two-thirds of the mutations in human cancers. All of these results are consistent with epidemiological estimates of the fraction of cancers that can be prevented by changes in the environment. Moreover, they accentuate the importance of early detection and intervention to reduce deaths from the many cancers arising from unavoidable R mutations.

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…using health records from 69 countries, they conclude that **66 percent** of cancer-causing genetic mutations **arise from the “bad luck”** of a healthy, dividing cell making a **random mistake** when it copies its DNA.
In our study we started from two well-known facts
It is well known that the distribution of IQ (intelligence quotient) has a Gaussian (normal) shape. The term IQ test actually refers to a number of different standardized tests designed to measure human intelligence. These tests focus on non-specific knowledge and skills, rather than facts and calculations. For example, most IQ tests include visual-based and verbal-based questions that highlight reasoning skills, rationality, mathematics, spatial skills, problem-solving, pattern recognition, retention and memory, multi-tasking, and logic. This broad scope of examination is intended to exclude or disadvantage as few test-takers as possible.

Vilfredo Federico Damaso Pareto, born in Italy in 1848, was a famous economist. He noticed that 20% of the pea plants in his garden generated 80% of the healthy pea pods. This observation caused him to think about uneven distribution. He thought about wealth and discovered in 1906 that 80% of the land in Italy was owned by just 20% of the population. He investigated different industries and found that 80% of production typically came from just 20% of the companies.

The Pareto law is an illustration of a "power law" relationship, which also occurs in phenomena such as forest fires, avalanches, earthquakes and other natural phenomena close to criticality.
Our *Talent* vs *Luck* model

- Working life period of **40 years**
- **1000 agents** considered and uniformly distributed in a square lattice
- Agents have a **normal (Gaussian) distribution of talent**
- Agents during their life period can encounter **lucky** (green points) or **unlucky** events (red points) uniformly distributed and with equal probability of occurrence
- **Check** of lucky or unlucky event occurrence **every 6 months**
- All agents have the same **initial capital of 10 units**
Dynamics of the model

1. A **lucky** event intercepts the position of agent $A_k$: this means that a lucky event has occurred during the last six month; as a consequence, agent $A_k$ doubles her capital/success with a probability proportional to her talent $T_k$.

   It will be $C_k(t) = 2C_k(t - 1)$ only if $\text{rand}[0,1] < T_k$,
   i.e. if the agent is smart enough to profit from her luck.

2. An **unlucky** event intercepts the position of agent $A_k$: this means that an unlucky event has occurred during the last six month; as a consequence, agent $A_k$ halves her capital/success, i.e.

   $C_k(t) = C_k(t - 1)/2$
Talent vs Luck (TvL) model

N = 1000 individuals (agents), with different degrees of talent (intelligence, skills, endurance, etc.), are randomly located in fixed positions within a square world.

During each simulation, which covers 40 years, they are exposed to a certain number $N_E$ of lucky (green circles) and unlucky (red circles) events, which move across the world following random trajectories (random walks).
Normal distribution of talent (skill, endurance, hard work, etc)

Normal distribution of talent among the population with mean $m_T = 0.6$, and standard deviation $\sigma_T = 0.1$

The values $m_T \pm \sigma_T$ are indicated by two dotted vertical lines.

This distribution does not change during the simulation.
First Results

The most successful individuals are not the most talented ones, but those with an average talent!
Results averaged over 100 runs

Panel (a): Distribution of the final capital/success, *averaged over 100 runs* for a population with different random initial conditions. The distribution can be well fitted with a power-law curve with a slope $-1.33$.

Panel (b): The final capital of the most successful individuals in each of the 100 runs is reported as function of their talent.

*Agents with a medium-high talent result to be, on average, more successful than people with low or medium-low talent.*

Very often the most successful individual is a moderately gifted agent and only rarely the most talented one!
Distribution of most successful agents

The most successful individuals over 10000 runs are almost never the most talented ones!
So there is a **Big Problem**:

if we use *Success/Capital* as a proxy for *Talent*,
we risk to give funds, rewards, honors, etc.

**NOT** to the *most talented individuals,*

**BUT** to the *luckiest ones* ("naive meritocracy")
Question

Is it possible to **distribute funds periodically** in order to give **another possibility** to the **most talented agents** to be able to emerge and be successful?
$E_{ff} = \frac{\text{Increment of talented people (T}>0.7\text{) with respect to the no funding case}}{\text{Total given funding}}$
Best strategies to distribute new funds to agents

<table>
<thead>
<tr>
<th>FUNDING-TARGET</th>
<th>$E_{norm}$</th>
<th>$P_T$</th>
<th>$P^*<em>T = P_T - P</em>{T0}$</th>
<th>$F_T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL EQUAL 1u</td>
<td>1,00</td>
<td>69,48</td>
<td>37,43</td>
<td>8000</td>
</tr>
<tr>
<td>10% RANDOM 5u</td>
<td>0,85</td>
<td>49,83</td>
<td>17,78</td>
<td>4000</td>
</tr>
<tr>
<td>25% RANDOM 5u</td>
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<td>68,00</td>
<td>35,95</td>
<td>10000</td>
</tr>
<tr>
<td>ALL EQUAL 2u</td>
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<td>84,02</td>
<td>56,97</td>
<td>16000</td>
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<tr>
<td>50% RANDOM 5u</td>
<td>0,58</td>
<td>82,91</td>
<td>50,86</td>
<td>20000</td>
</tr>
<tr>
<td>25% BEST 5u, OTHERS 1u</td>
<td>0,37</td>
<td>73,44</td>
<td>41,39</td>
<td>26000</td>
</tr>
<tr>
<td>25% BEST 10u, OTHERS 1u</td>
<td>0,37</td>
<td>94,40</td>
<td>62,35</td>
<td>40000</td>
</tr>
<tr>
<td>ALL EQUAL 5u</td>
<td>0,37</td>
<td>94,40</td>
<td>62,35</td>
<td>40000</td>
</tr>
<tr>
<td>25% RANDOM 20u</td>
<td>0,31</td>
<td>84,74</td>
<td>52,69</td>
<td>40000</td>
</tr>
<tr>
<td>50% BEST 5u</td>
<td>0,25</td>
<td>54,26</td>
<td>22,21</td>
<td>20000</td>
</tr>
<tr>
<td>25% BEST 10u, OTHERS 5u</td>
<td>0,21</td>
<td>94,82</td>
<td>62,77</td>
<td>70000</td>
</tr>
<tr>
<td>25% BEST 5u</td>
<td>0,20</td>
<td>41,08</td>
<td>9,03</td>
<td>10000</td>
</tr>
<tr>
<td>25% BEST 10u</td>
<td>0,12</td>
<td>42,33</td>
<td>10,28</td>
<td>20000</td>
</tr>
<tr>
<td>10% BEST 5u</td>
<td>0,10</td>
<td>34,14</td>
<td>2,09</td>
<td>4000</td>
</tr>
<tr>
<td>25% BEST 15u</td>
<td>0,09</td>
<td>43,51</td>
<td>11,46</td>
<td>30000</td>
</tr>
<tr>
<td>25% BEST 20u</td>
<td>0,07</td>
<td>44,26</td>
<td>12,21</td>
<td>40000</td>
</tr>
<tr>
<td>10% BEST 10u</td>
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<td>34,41</td>
<td>2,36</td>
<td>8000</td>
</tr>
<tr>
<td>10% BEST 20u</td>
<td>0,04</td>
<td>34,98</td>
<td>2,93</td>
<td>16000</td>
</tr>
<tr>
<td>NO FUNDING</td>
<td>0,00</td>
<td>32,05</td>
<td>0,00</td>
<td>0</td>
</tr>
</tbody>
</table>

$P_T=$ Percentage of talented people ($T > 0.7$) with a final capital greater than the initial one

$P^*_T=$ Percentage of talented people ($T > 0.7$) with a final capital greater than the initial one with respect to the case of no funding $P_{T0}$

Funding strategy table with the efficiency index $E_{norm}$ (averaged over 100 runs) in decreasing order and for different total capital distributed $F_T$

The egalitarian and the random strategies are the most efficient ones!
Best strategies to distribute funds to agents

<table>
<thead>
<tr>
<th>FUNDING-TARGET</th>
<th>$E_{\text{nom}}$</th>
<th>$P_T$</th>
<th>$P'<em>T = P_T - P</em>{T0}$</th>
<th>$F_T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL EQUAL</td>
<td>1,00</td>
<td>98,14</td>
<td>67,68</td>
<td>80000</td>
</tr>
<tr>
<td>50% RANDOM</td>
<td>0,98</td>
<td>97,12</td>
<td>66,66</td>
<td>80000</td>
</tr>
<tr>
<td>HALF 25% BEST, HALF TO OTHERS</td>
<td>0,97</td>
<td>96,13</td>
<td>65,67</td>
<td>80000</td>
</tr>
<tr>
<td>25% RANDOM</td>
<td>0,85</td>
<td>87,67</td>
<td>57,21</td>
<td>80000</td>
</tr>
<tr>
<td>10% RANDOM</td>
<td>0,54</td>
<td>66,73</td>
<td>36,27</td>
<td>80000</td>
</tr>
<tr>
<td>50% BEST</td>
<td>0,45</td>
<td>61,19</td>
<td>30,73</td>
<td>80000</td>
</tr>
<tr>
<td>25% BEST</td>
<td>0,22</td>
<td>45,31</td>
<td>14,85</td>
<td>80000</td>
</tr>
<tr>
<td>10% BEST</td>
<td>0,06</td>
<td>34,83</td>
<td>4,37</td>
<td>80000</td>
</tr>
<tr>
<td>NO FUNDING</td>
<td>0,00</td>
<td>30,46</td>
<td>0,00</td>
<td>0</td>
</tr>
</tbody>
</table>

Funding strategy table with a fixed quantity of funds $F_T=80000$ units

Also in this case the egalitarian strategy and the random one are at the top of the ranking!
Giving funds and resources to those most successful in the past, “naive meritocracy”, is not only unfair (since these are often only the most lucky ones), but it does not pay in terms of further success and innovation.
Encouraging diversity instead of Excellence or Conformism produces a better research!

Science benefits from diversity

Improving the participation of under-represented groups is not just fairer — it could produce better research.

Lab groups, departments, universities and national funders should encourage participation in science from as many sectors of the population as possible. It’s the right thing to do — both morally and to help build a sustainable future for research that truly represents society.
On the other hand, it has recently been realized that, notwithstanding the huge proliferation of publications, there are several indications of conformity...and decline of disruptiveness in Science in the last decades

(See Nature paper January 2023)
Recently the suggestion to give funds by using a random selection of projects with a minimum level of quality prerequisites has been advanced by several parts!
Recently the suggestion to give funds by using a random selection of projects with a minimum level of prerequisites has been advanced by several parts!

Q&A: A Randomized Approach to Awarding Grants

Denmark’s Novo Nordisk Foundation says it hopes that adding a randomization step to its award process will reduce implicit biases in selection and lead to funding more innovative, impactful research.

The Novo Nordisk Foundation, one of the largest private scientific research funders in the world, announced last month that it would begin employing a partial randomization system to fund some types of research projects. In the next three years, the Copenhagen-based funding agency will use a combination of committee selection and a lottery system to choose some of the awardees of its $500,000 Project Grants in fields of biomedicine, biotechnology, and natural and technical sciences, as well as its $800,000 Exploratory Interdisciplinary Synergy Grants. Together, these grants comprise roughly 10% of the organization’s total research project funding, says Lene Oddershede, the senior vice president of natural and technical sciences at the Novo Nordisk Foundation, who oversees the grant funding process. She says she hopes that the partial randomization system will reduce conscious and unconscious bias in the committee selection process and improve funding inequities.

“I think most researchers want to see that the applications are treated in a fair manner and in a transparent manner,” says Oddershede. Scientists also want to ensure “that the best research is funded, of course,” she says, “but what is best research?”

In Denmark, 90 percent of the funding goes to just 20 percent of researchers, and a similar concentration exists in many countries. According to recent studies in the United States, for instance, funding inequities have increased in the past decade. In 2020, the top 1 percent most
Recently the suggestion to give funds by using a random selection of projects with a minimum level of prerequisites has been advanced by several parts!
Conclusions

➤ I have presented a simple toy model which is able to reproduce several stylised facts about the role of lucky events in order to reach success in life and science.

➤ The model shows that the most talented people are rarely the most successful, the latter being usually those with an average talent.

➤ Risks of “naive meritocracy”!

➤ By adopting funding strategies that give new opportunities to everybody, instead of rewarding only those who were the most successful in the past, it is possible to foster both the emergence of the most talented ones and more innovative ideas with a benefit for the single individuals, but also for science progress and for the entire society.
One last point: In order to have a beautiful garden...

...is it better to water only a few beautiful (excellent) plants...

...or to give water to all the plants?

I think you know the answer!
So now and then, it is better to give a chance also to apparently out-of-the-box ideas… they may not be so crazy after all.
Science funding has to risk in order to foster innovation!!

Someone once said…
"He did not know he could not do it, but he did it and he succeeded!!"

At the beginning of 1900

A few decades later…
This study was very lucky ... and it got a great and unexpected amount of attention among scientists and social media since it was posted online as a preprint in 2018.
Ig Nobel prize for Economics 2022

TALENT VERSUS LUCK: THE ROLE OF RANDOMNESS IN SUCCESS AND FAILURE

ALESSANDRO PLUICCHIO
Department of Physics and Astronomy
University of Catania
Via S. Sofia 54, Catania 95123, Italy
INLEN-CT, Via S. Sofia 84, Catania 95123, Italy
alessandro.pluchino@lnf.infn.it

ALESSIO EMANUELE BIONDO
Department of Economics and Business
University of Catania
Corso Italia 85, Catania 95129, Italy
a.biondo@unct.it

ANDREA RAPISARDA
Department of Physics and Astronomy
University of Catania

The 32nd First Annual Ig Nobel Prize Ceremony
You can find more info on this project at following link:  
http://www.andrea-rapisarda.it/talent-vs-luck

Talent vs Luck
Talent vs Luck: The Role of Randomness in Success and Failure
Our first paper
Advances in Complex Systems - Vol. 21, No. 03n04, 1850014 (2018)

On September 15, 2022 the paper was awarded with the Ig Nobel prize for Economics
(see link)
Thanks for your attention and ...