Is scientific discovery driven by great individuals or by great teams?

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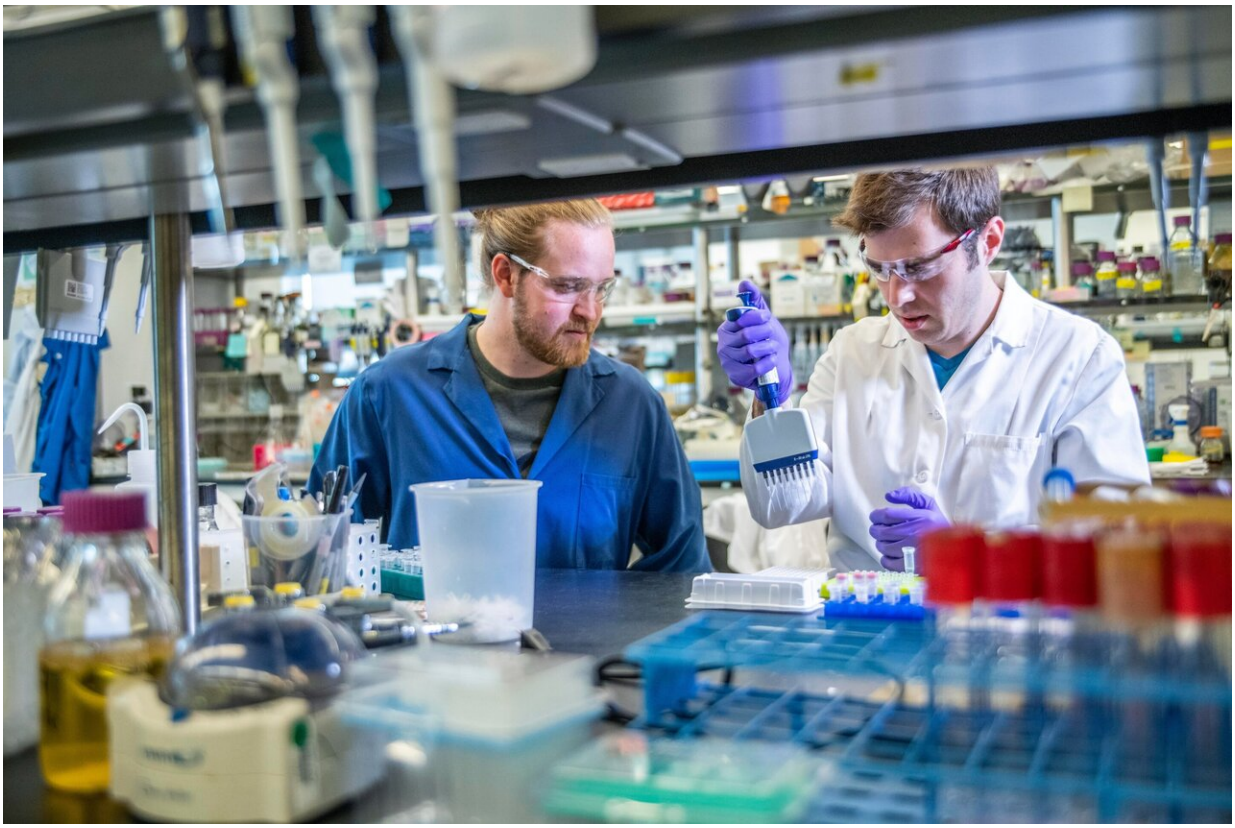

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"This isn't mine; this is one for the team," said Succession star Kieran Culkin as he accepted the Best Actor award at this year's Golden Globes. It's a familiar aspect of Hollywood awards speeches—a reminder that the stars dazzling us on screen could not exist without the people who support them. "It's been said, but it's a team effort, this show," said Succession creator Jesse Armstrong at the awards, underlining the same sentiment.

Hollywood speeches aside, we do seem to focus on individuals when we acknowledge greatness. In business and science, the dominant cultural narrative is that the bulk of innovation is driven by a handful of exceptional individuals, or "stars." We elevate pioneers like Steve Jobs or Albert Einstein, and reward individuals who show similar promise with resources that allow them to continue performing high-value work.

Star scientists are those who publish significantly more than their peers, producing papers with greater impact and actively participating in commercialization ventures. However, science is rarely a solo effort. Even star scientists usually have a team—a "constellation"—of collaborators behind them. Research teams have grown in size by 50% in the period between 1981 and 1999.

In recent years, more than 80% of all science and engineering publications and over two-thirds of patents have been the product of multiple authors. Research collaborations that include star researchers typically achieve higher average performance than those without such individuals.

But what is the maximum impact that a single person can have on the joint performance of a collaboration? We examined the relative contributions individuals and their collaborators make to scientific

innovation to understand how to optimize team composition to best perform.

How star researchers improve collective performance

Star researchers improve collective performance in two ways. First, the presence and contributions of the star researcher improve the quality and output of their collaborators, leading to greater overall team success. Previous approaches have studied this so-called spillover effect by examining what happens when a star scientist leaves the group. These studies showed that when this happened, colleagues experienced a lasting 5-10% decline in publication rate.

Second, once a researcher has initial success, they find it increasingly easy to attract talent and resources. This is called the "Matthew effect," named after a (loose) interpretation of a Biblical parable.

In practice, the Matthew effect reflects a feedback loop wherein star researchers can increase their success at a greater rate than their peers. It has been borne out by studies showing that star scientists gain preferential access to valuable resources like funding, talented graduate students, and advanced lab facilities in both in academia and in the private sector.

30 star scientists and their constellations

Prior research has treated spillover and the Matthew effect separately, but they are inextricably linked. So, we developed a model to capture this complexity.

We investigated the star-constellation relationship in collaborations that resulted in an invention. University researchers must disclose new

inventions to their institutions. Because the disclosure is a legal document, it's useful for our research because it sidesteps social noise such as favors and institutional politics that may skew rates of publication authorship. The data was taken from a U.S. university with a renowned medical school.

Analysis was performed using data on the 555 invention disclosures that were registered between 1988 and 1999. From the total cohort of 1003 scientists, of which 248 were team leaders, we identified a cohort of 30 "stars" who were in the top 5% of globally cited researchers.

Irreplaceable stars

The contribution of a star scientist to a team is dominant—i.e. their contribution exceeds that of their team—when they are "irreplaceable." This means that they are so well-matched to the rest of the team that the constellation would be unable to produce work of the same standard without them, even with a new leader.

What makes a leader "well matched" to their team? We looked for trends in the dataset, considered the research impact, knowledge profile, and the range of seniorities in the group, so we could determine what matters the most when scientists choose collaborators.

We found that high-value team leaders tend to work with high-value collaborators, supporting the theory that star scientists attract talented constellations. Further, prominent leaders have access to, and are preferred by, collaborators with whom they share some expertise overlap, though a very high similarity makes the collaboration less favorable. Some common language and goals are a strength, but too much overlap in expertise stifles innovation.

In addition, high-value team leaders tend to work in groups where

scientists of both senior and junior ranks come together. We therefore argue that diversity of perspectives and skills enables discovery. Last but not least, star scientists and their collaborators tend to share the same research profile with respect to the application domains of their research.

Star's surprisingly small contribution

We used these findings to investigate whether the star or constellation makes the greater contribution to scientific discovery. When a star and constellation are well-matched, they produce higher quality research. For each collaboration, we calculated whether the star or constellation would be harder to replace.

To calculate the replaceability, we replaced a star or constellation with the substitute that was the second-best match. The greater the loss in research impact, the more irreplaceable the missing star or constellation was to the research.

Surprisingly, results show that it is rare for a single person to make a more impactful contribution than their team. The relative contribution the star makes to knowledge creation surpasses the constellation's in only 14.3% of collaborations. The constellation is the dominant party, in terms of relative value creation, in only 9.5% of cases. In more than three-quarters of cases, neither party dominates, with complementarity between star and constellation maximizing research value. In almost every pairing, innovation was a collective endeavor.

In short, to identify the drivers of innovation and discovery, we should not allow our view of the entire sky to be eclipsed by a few very bright stars.

Championing the whole team

Scientists perceived to bring star qualities are in demand and are often induced to transfer from one institution to another. This research suggests that administrators should endeavor to enable stars to move with their teams. Adjusting to work without their collaborators may have an adverse effect on the scientist's research and their ability to attract additional talented hires. Dominating stars suffer a smaller loss without their team, but they are getting a bigger piece of a smaller pie.

However, the most significant takeaway for this research is that research credit is unfairly biased towards prominent individuals. Star scientists undoubtedly drive innovation, and a minority brings irreplaceable value. However, when considering the research output of a star, their achievements should be looked at within the context of a team. In most cases, the constellation brings a high contribution that merits recognition with IP credits, financial rents and other resources.

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