Interdisciplinarity and specialisation: Roads to scientific success

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Previous work has examined the advantages that scientists gain from specialisation in terms of research productivity, promotion, tenure standards, and academic earnings. On the other hand, research has also suggested that exposure to diverse sources of knowledge stimulates creativity, facilitates innovation, enables individuals to solve complex and multi-faceted problems, and sustains novel recombinations of multiple ideas, theories, and methods from various fields. At the same time, recent studies have indicated that teams typically produce more frequently cited research than individuals do. However, relatively little attention has been devoted to the way multi-authorship combines with access to knowledge to affect scientists' research performance. Scientists can select their collaborators within their own research fields to strengthen their skills, enhance consensus on scientific standards and techniques, and facilitate the generation of shared norms of research practice. Alternatively, scientists can produce interdisciplinary work by engaging in collaborations with other scientists from different fields. Despite the ubiquity of interdisciplinary collaborations, research has largely overlooked the collaboration patterns through which scientists produce interdisciplinary work, and how these patterns ultimately affect research performance. In this paper, we take a step in this direction, and investigate whether and the extent to which disciplinary fields and collaboration networks combine to affect scientists' career trajectories and ability to produce work of high impact.

Our study draws upon the collaboration network of the scientists that authored or co-authored all articles published in the Physical Review journals of the American Physical Society from 1975 to 2009. We also extract the number of citations received by scientists over time, and the self-assigned categories of research fields, namely the Physics and Astronomy Classification Scheme (PACS) codes appearing in the publications. For each scientist i, we measure the background interdisciplinarity by computing the Shannon entropy B_i over the set of the scientist's PACS codes extracted from his or her publications. We also investigate the extent to which collaboration networks enable scientists to expand the breadth of their interdisciplinarity by offering access and exposure to a variety of disciplinary fields. To this end, for each scientist i we measure the social interdisciplinarity by evaluating the Shannon entropy S_i over the set of PACS codes appearing in all publications of the scientist's collaborators.

Results indicate that scientists cannot improve their performance simply by expanding the breadth of their background interdisciplinarity. While specialisation (i.e., $B_i \sim 0$) is associated with scientific success, only high degrees of interdisciplinarity (i.e., $B_i \gtrsim 1$) can amplify scientists' performance. Moderate levels of interdisciplinarity (i.e., $B_i \sim 0.5$) are instead likely to hinder performance. Moreover, when scientists choose to broaden their horizons through their collaborators, they can improve their performance by forging collaboration networks that span a wide variety of disciplinary fields (i.e., $S_i \gg 0$). We examine the interplay between background and social interdisciplinarity, and find that very successful scientists (i.e., those with citations $> 1,000$) tend to align the disciplinary breadth of their work with their collaboration networks. If they specialise in their fields, they tend to choose collaborators that share the same fields, whereas if they are interdisciplinary, they choose collaborators across multiple fields. We then analyse collaboration strategies over time, and identify those leading to high levels of interdisciplinarity and success. Results suggest that successful scientists, once exposed to new knowledge, tend to absorb it from their collaborators to a greater extent, yet at a lower pace, than less successful scientists do. Moreover, successful scientists enhance interdisciplinarity not so much by absorbing collaborators' experience as by promoting synergies with them that sustain the creation of new knowledge. Implications of our findings for research on collaboration networks and strategies, interdisciplinarity, and the structural foundations of scientific production are discussed.