Who reviews for interdisciplinary research? A Study based on Active Reviewers from Publons

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Abstract: The increasing importance of interdisciplinary research presents challenges in evaluating the quality of such research, and the urgency for academic journals to select appropriate interdisciplinary reviewers. We conducted a study examining the research, reviewing, and editorial activities of top reviewers in the Cross-field category (abbreviated as active interdisciplinary reviewers) provided by Publons. Our findings indicate that active interdisciplinary reviewers are often highly interdisciplinary researchers, and a significant correlation between the interdisciplinarity of their research and reviewing activities reinforces this observation. Moderately experienced reviewers are the primary force behind interdisciplinary reviewing, and senior reviewers with longer research and reviewing experience are particularly advantageous for studies with knowledge across multiple disciplines. Based on our results, we recommend prioritizing reviewers for interdisciplinary research who demonstrate higher interdisciplinarity in both research and reviewing activities, as they may have better reviewing performance.

1. Introduction
As modern science continues to evolve and broaden, the resolution of boundary-crossing problems and the findings of high novelty frequently necessitate the integration of multiple disciplines, interdisciplinary research has emerged as a driving force for propelling scientific innovation. However, evaluating the quality of such research can be challenging, given its interdisciplinary nature. In the process of journal publishing, peer review is essential to invite experts in the same field to evaluate scientific discoveries and offer constructive feedback to improve the manuscript, thereby ensure the quality of published research and enhance the credibility of scientific claims (Bornmann, 2008). However, many researchers suspect that interdisciplinary research may encounter unduly critical reviews or scholarly/professional bias during the peer review process, which hinder innovation and development in interdisciplinary research (Grit & Gloria, 2006; Liv, 2006; MacLeod, 2018; Michèle et al., 2006).

As gatekeepers of academic journals, reviewers play a crucial role in the peer review process (Amber, 2022; Jubb, 2016). Most journals’ peer review processes are confidential and undisclosed. This confidentiality poses a challenge for current scientific journals to identify potential and suitable reviewers based on their review performance and relevant qualifications, as they may have to rely on a pool of reviewers familiar to the editors. However, with the increasing prevalence of interdisciplinary research, the restricted pool of potential reviewers might lack familiarity with emerging research fields, potentially resulting in diminished review quality. As stated in the 2018 Publons Global State of Peer Review, 75% of journal editors say that finding reviewers is the hardest part of their work (Publons, 2018). The rising number of paper submissions has resulted in an increased workload for reviewers, exacerbating this issue (Diamandis, 2017; Fox & Burns, 2015; Jorm, 2022; Michail et al., 2016). This predicament
underscores the pressing need for academics or academic journals to select appropriate reviewers, particularly in interdisciplinary research.

To address these challenges, Publons has developed a system that rewards the top 1% of reviewers in each of the 22 Essential Science Indicators (ESI) research fields for their contributions, with “contributions” referring to the reviewers who have conducted the highest number of reviews in corresponding fields. In 2019, this rewards includes reviewers of “Cross-field”, who are top 1% of reviewers in the Multidisciplinary ESI research field or reviewers who performed multiple reviews across various ESI fields. By analyzing the profiles of active interdisciplinary reviewers who received the “2019 Top 1% in Cross-field” award, this study aims to investigate the following research questions:

(1) What are the characteristics of active reviewers in interdisciplinary fields?
(2) Do active reviewers in interdisciplinary fields possess interdisciplinary backgrounds themselves?
(3) How do the research, reviewing, and editorial activities of active reviewers in interdisciplinary fields interact?

2. Data and Methodology
2.1. Data source
The data sample of active interdisciplinary reviewers consists of the 2019 Top 1% Reviewers in Cross-field (awarded to 3080 reviewers) and was gathered through Publons’ API from January 19, 2022, to January 26, 2022. Each reviewer’s profile displays their review metrics, current editorial board memberships, and a unique Clarivate-wide Researcher ID. Since the publications provided by Publons may be incomplete, we chose to retrieve and download comprehensive publication spanning 1900-2021 from WoS using the reviewers’ unique Researcher IDs. To supplement our dataset for reviewers lacking a Researcher ID, we employed ORCID as an alternative identifier. Publons data is manually maintained by reviewers, who have the option to decide whether to make their review-related information public by using the privacy settings function provided by Publons. Therefore, we excluded reviewers with incomplete basic information, zero publication or review records. This resulted in a final dataset comprising 1,074,465 verified reviews, 223,228 publications, and 5,679 ‘Editorial board memberships’ records of 2,067 reviewers. The term “reviewers” in the following text refers to the interdisciplinary reviewers in our sample.

2.2. Main indicators
(1) Indicators for research, reviewing and editorial activities
We used counted publications (#Publications) as a reflection of research activity, the number of verified reviews (#Reviews) to measure reviewing activity, and the number of journals currently serving on editorial boards (#Editorial_Journals) to assess editorial activity. We obtain from Incites the ESI category of each journal that research, reviewing, and editorial activities contribute to. In addition to these measures, we included research experience and reviewing experience variables to account for the length of a researcher’s career, calculated as

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2 Each reviewer has a research profile which is populated with data drawn from WoS after Publons was acquired by Clarivate Analytics in 2017.
3 https://orcid.org/.
4 There are 276 reviewers lacked a Researcher ID in their Publons profile, with 106 of them having the ORCID which we used to obtain supplementary publication data, resulting in a total of 2910 reviewers with their review and publication records. After removing 161 reviewers without basic information of country/region and institution, and 142 reviewers with no review or publication records, the final data set contains 2607 reviewers.
5 InCites is based on a single dataset sourced from WoS, encompassing data from ESI and Journal Citation Reports (JCR), which allows us to classify journals into a single ESI category. Among the datasets, 76.18% of the reviews, 96.65% of the publications, and 47.95% of the editorial journals have ESI subject categories.
the difference between 2021 and the year of first publication or first review on Publons, respectively.

(2) Indicators for interdisciplinarity
We use variety and Simpson index to measure interdisciplinarity. Variety is defined as the number of research fields that records are assigned to by ESI categories. Simpson Index (SI) combines disciplinary variety and evenness to describe the diversity of the fields of research (Rafols & Meyer, 2010), calculated as:

\[ SI = 1 - \sum P_i^2 \]  

Where \( P_i = x_i/X; X = \sum x_i \); \( x_i \) is the number of records assigned to the \( i \)-\( th \) subject categories based on ESI subject categories. The value of SI ranges from 0 to 1, which indicates minimum and maximum diversity, respectively. In the case of one single category tag in a group, the value of Simpson’s index is 0.

(3) Indicators for disciplinary similarity between different academic activities
Disciplinary similarity method (Jia et al., 2017) was used to measure the consistency among the categories of reviewers’ research, reviewing, and editorial activities. We composed vectors based on publication, review, and editorial journal records to represent different academic activities. The vector has 22 dimensions corresponding to each of the 22 ESI subject categories, and \( subject_i \) is the number of records in the \( i \)-\( th \) subject categories, the similarity is the cosine similarity between two vectors, calculated as:

\[ Vector = (subject_1, subject_2, subject_3 \cdots subject_{21}, subject_{22}) \]  

\[ Similarity(publication, review) = \cos(publicationVector, reviewVector) \]  

The degree of similarity between two vectors is measured by a value ranging from 0 to 1, where a higher value indicates a stronger similarity.

3. Results

3.1. Characteristics of active reviewers in interdisciplinary fields
(1) By country/region
Exploring the characteristics of reviewers from different countries, our analysis investigates the countries from which active interdisciplinary reviewers originate. Figure 1 presents a map that visualizes the number of active reviewers and average review length by country. The variation in colors indicates the number of reviewers. The distribution of the top ten countries (enumerated in descending order from left to right) with the highest number of reviewers in this study is almost consistent with other studies based on Publons (Pomponi et al., 2019; Zhang et al., 2022). It is noteworthy that emerging countries such as China, India, and Iran have attained higher rankings than some well-established countries and have made substantial contribution to global review process. Collectively, the top 10 countries account for 57% of the world’s reviewers and are responsible for 55.51% of the world’s total reviews. This supports the findings that there exists an imbalance in peer review efforts within the scientific community (Michail et al., 2016), with a few countries undertaking the majority of global reviewing work.

In our analysis, active interdisciplinary reviewers produce an average review length of approximately 308 words, which is shorter than the average length of review reports provided by Publons (477 words). This discrepancy may arise due to the complexity and innovation associated with interdisciplinary research, stemming from the integration of multidisciplinary knowledge, which may pose challenges for reviewers in assessing manuscripts. Shorter reviews can be observed in emerging countries such as China (259 words), India (246 words), and Iran (222 words), potentially attributable to lower English proficiency among reviewers in these regions. China, India, and Iran are placed in the Moderate and Low Proficiency categories,
according to the Education First English Proficiency Index (EF EPI), ranked 62, 52, and 69, respectively\(^6\).

Figure 1: The average review length of reviewers in the ten countries with the most reviewers

![Map showing average review length and reviewers in ten countries]

(2) By institution

Our analysis of reviewer institutions categorizes them into university and non-university based on whether they include certain terms in their names\(^7\). Figure 2 shows that 2052 (78.71\%) reviewers are from universities, account for 81.19\% of all review records, while 555 (21.29\%) are from non-universities. Further analysis of the ranking of the universities reveals that 32.85\% of reviewers are affiliated with universities not included in the 2022 QS World University Rankings, while 865 reviewers (62.77\%) of the remaining reviewers were from the top 500 universities worldwide\(^8\). This tendency to invite reviewers from reputed universities and perceived to provide high-quality reviews aligns with a particular implicit perception of peer review within journals (Gasparyan & Kitas, 2012). Moreover, we should not disregard the contribution made by non-universities to the global review process.

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\(^6\) The EF EPI is the world’s largest ranking of countries_regions by adult English skills, EF EPI Report 2022 was retrieved from: [https://www.ef.edu/assetscdn/WIBIwq6RdJvcD9bc8RMd/cefcom-epi-site/reports/2022/ef-epi-2022-english.pdf](https://www.ef.edu/assetscdn/WIBIwq6RdJvcD9bc8RMd/cefcom-epi-site/reports/2022/ef-epi-2022-english.pdf)

\(^7\) Institutions that do not include the terms “university” or “school” in their names are labeled as non-university, while those that do are classified as universities. In cases where the words “medical/health center” or “hospital” are present, the institution is also considered a non-university.

\(^8\) [https://www.topuniversities.com/university-rankings/world-university-rankings/2022](https://www.topuniversities.com/university-rankings/world-university-rankings/2022)
(3) By research fields
Active reviewers received awards not only in Cross-Field but also in 21 other ESI research fields, except for Space Science. Out of 2,607 top reviewers, 667 exclusively received awards in Cross-field, while 74.42% received two or more awards in different ESI research fields. This indicates substantial interdisciplinary characteristics in their reviewing activities. Further analysis of the research, reviewing, and editorial activities based on the ESI categories. As shown in Figure 3, these activities primarily concentrate in Chemistry, Clinical Medicine, and Engineering fields. Chemistry has the highest percentage of publications (20.37%), while review activities predominantly concentrate in Engineering (15.56%), and scholars mainly serve as editorial board members in Clinical Medicine (21.81%). This illustrates the interdisciplinary characteristic in reviewers’ academic activities.
3.2. Interdisciplinarity of reviewers

To investigate whether active interdisciplinary reviewers also have interdisciplinary research profiles, we use Simpson index and variety to measure the interdisciplinarity of their research activities (#Publications), reviewing activities (#Reviews), and editorial activities (#Editorial_Journals) across different ESI categories. We note that we could only obtain statistics for editorial activities from a sample of 1356 (52%) individuals (as only they served on journal boards). Table 1 indicates that reviewers exhibit high variety and Simpson index in their research and reviewing endeavors, but not in their editorial work. This may be attributed to the heavy workload editorial board members undertake. They need to evaluate the content of huge number of manuscripts submitted to the journal and reviewers' feedback (Teixeira da Silva & Al-Khatib, 2017). Thus, serving on multiple journals' boards across various categories is more challenging than reviewing and publishing in various fields. Overall, our findings suggest that active reviewers are highly interdisciplinary researcher with diversified review activities, albeit not so much in their editorial duties.

Table 1. Descriptive statistics of interdisciplinary indicators of three academic activities

9 The research fields with △ are the fields with highest contribution of reviewers’ research, reviewing, and editorial activities.
(2) Different research experience and reviewing experience groups
We investigate the variation in academic activities of interdisciplinary reviewers across different research and reviewing experience. The statistical analysis revealed a mean research experience of 15 years and a mean reviewing experience of 8 years. Research experience is significantly longer than reviewing experience, aligning with the notion that reviewers typically begin receiving review invitations and participating in the review process after accumulating a certain amount of academic output. As shown in Table 2, the distribution of reviewing experience is concentrated between 6 and 10 years, indicating that moderately experienced reviewers are the main force of interdisciplinary awarded reviewers. This may indicate that moderately experienced reviewers among interdisciplinary reviewers are more willing to invest more time and effort in review activities, making them an excellent candidate group of reviewers.

Table 2. The number and proportion of reviewers by reviewing experience and research experience

<table>
<thead>
<tr>
<th>Research experience (Year)</th>
<th>No. of reviewers in sample</th>
<th>Proportion (%)</th>
<th>Reviewing experience (Year)</th>
<th>No. of reviewers in sample</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤5</td>
<td>288</td>
<td>11.05</td>
<td>≤5</td>
<td>600</td>
<td>23.01</td>
</tr>
<tr>
<td>6~10</td>
<td>691</td>
<td>26.51</td>
<td>6~10</td>
<td>1478</td>
<td>56.69</td>
</tr>
<tr>
<td>11~15</td>
<td>601</td>
<td>23.05</td>
<td>11~15</td>
<td>429</td>
<td>16.46</td>
</tr>
<tr>
<td>16~20</td>
<td>408</td>
<td>15.65</td>
<td>16~20</td>
<td>86</td>
<td>3.30</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>619</td>
<td>23.74</td>
<td>&gt; 20</td>
<td>14</td>
<td>0.54</td>
</tr>
</tbody>
</table>

We further investigate the interdisciplinarity across different groups of research and reviewing experience, as depicted in Figure 4. As reviewers’ research and reviewing experience increase, they tend to engage in research, reviewing, and editorial activities across multiple disciplines, resulting in heightened interdisciplinarity. The analysis also revealed that reviewers with longer research and reviewing experience exhibit higher variety and lower Simpson index in reviewing activities, compared to research activities. This may be attributed to the relatively lower difficulty in reviewing articles from other disciplines compared to integrating multiple disciplines for knowledge creation. Consequently, interdisciplinary scholars may primarily focus on a few disciplines for their research activities, while their reviewing activities tend to be more dispersed and uneven across multiple fields. This discrepancy explains the lower Simpson index of reviews, which calculates both disciplinary variety and unevenness. Based on our analysis, when selecting reviewers for studies with knowledge across multiple disciplines, it may be advantageous to consider senior reviewers with longer research and reviewing experience.
3.3. Interaction among research, reviewing and editorial activity

(1) Disciplinary similarity between different academic activities

Our findings indicate that interdisciplinary reviewers are typically interdisciplinary researchers, but there is uncertainty regarding the consistency of their three academic activities. Therefore, we constructed disciplinary vectors based on the disciplines of their publication, review, and editorial journal records, and calculated the disciplinary similarity among their academic activities. We must note that the disciplinary vectors for editorial activities could only be created for 1047 reviewers, as some journals lacked ESI categories. The results, which are presented in Table 3, suggest that reviewers' research, reviewing, and editorial activities exhibit substantial similarity, especially in terms of their research and reviewing activities.

Table 3. Descriptive statistics of disciplinary similarity between research, reviewing and editorial activities

<table>
<thead>
<tr>
<th>Type</th>
<th>No. of reviewers in sample</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publications-Reviews similarity</td>
<td>2607</td>
<td>0.89</td>
<td>0.96</td>
<td>0.16</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Reviews-Editorial Journals similarity</td>
<td>1047</td>
<td>0.78</td>
<td>0.91</td>
<td>0.27</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Publications-Editorial Journals similarity</td>
<td>1047</td>
<td>0.76</td>
<td>0.88</td>
<td>0.28</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

(2) Correlation analysis

To uncover the complex relationship between reviewers' research, reviewing, and editorial activities, we conducted an analysis using Spearman's correlation coefficient\(^\text{10}\). The findings, displayed in Figure 5, yielded several noteworthy results. Surprisingly, there is a significant correlation between reviewers' reviewing experience and the number of publications and reviews, while a weak correlation between research experience and the number of reviews. This indicates that scholars who have longer reviewing experience are often presumed to be productive researchers, whereas some scholars who have longer research experience may not

\(^{10}\) Spearman’s correlations were used because the data for the variables did not conform to a normal distribution.
devote themselves to review process. Furthermore, the correlation between the number of publications, reviews, and editorial journals was weak, implying that it is challenging for scholars to maintain high output in both publishing and reviewing activities. We also discovered a significant correlation between the Simpson index of publications and reviews, suggesting that scholars who actively participate in interdisciplinary research are more likely to conduct interdisciplinary reviews\textsuperscript{11}.

In conclusion, our analysis revealed a significant correlation between the interdisciplinarity of reviewers’ research and reviewing activities. These findings highlight the importance of selecting reviewers with longer reviewing experience, interdisciplinary research backgrounds and interdisciplinary reviewing records.

Figure 5: Correlation heat map between research, reviewing, and editorial activities (Spearman’s correlation coefficient)

(3) Distribution of interdisciplinary reviewers
In order to tackle the practical issue of selecting reviewers with interdisciplinary backgrounds, we conducted a study on the reviewing performance of active reviewers with dual interdisciplinarity. The reviewers were categorized into four quadrants based on the mean Simpson index of publications and reviews, and the average review length was indicated by node color in Figure 6 (a). The D quadrant, with high research interdisciplinarity and high reviewing interdisciplinarity, had the highest proportion of reviewers at 48.06%, while the A quadrant, with low research interdisciplinarity and low reviewing interdisciplinarity, accounted for approximately 30.19% of the reviewers. Reviewers in the D quadrant had longer review

\textsuperscript{11} Variety and Simpson index are two indicators used to assess interdisciplinarity. While variety is a one-dimensional measure, Simpson index is a two-dimensional measure that incorporates variety and unevenness, as explained in “Data and Methodology” section. Therefore, in the subsequent analysis, we rely solely on the Simpson index as a metric of interdisciplinarity.
lengths. In addition, we analyzed the contribution of reviewers from different quadrants in research, reviewing, and editorial activities in Figure 6 (b) and found that reviewers in the D quadrant made substantial contribution to reviewing and were more involved in editorial board. Therefore, we suggest giving preference to scholars with higher interdisciplinarity in both research and reviewing activities from those with interdisciplinary backgrounds. Such scholars may be more willing to accept review invitations and, in turn, demonstrate a high level of reviewing performance.

Figure 6: The distribution of reviewers in twofold interdisciplinarity

4. Discussion and Conclusion
Our study suggests that active interdisciplinary reviewers are mostly also interdisciplinary researchers, and as their reviewing and research experience increase, their reviewing and research activities tend to be more interdisciplinary. Moreover, there is a significant correlation between the interdisciplinarity of their research and reviewing activities. Given the mounting pressure on peer review, we offer several recommendations for selecting reviewers for interdisciplinary research based on our analysis. Firstly, the selection of reviewers should not be restricted to researchers from well-established countries and universities, as researchers from emerging countries and non-universities also play a nonnegligible role in the global review process. Second, when extending invitations to potential reviewers, priority may be given to moderately experienced reviewers who may have invested more time and efforts in review process and be more willing to accept. And when selecting reviewers for studies with knowledge across multiple disciplines, it may be advantageous to consider senior reviewers with longer research and reviewing experience. Third, since there is a significant correlation between the interdisciplinarity of reviewers’ research and reviewing activities, reviewers with interdisciplinary research backgrounds and interdisciplinary reviewing records can be preferred for interdisciplinary studies, especially those with higher interdisciplinarity in both research and reviewing activities who may possess more reviewing and editorial board experience and can provide more detailed review comments.

Our study has several limitations that should be acknowledged. Firstly, we only considered the quantity of reviews rather than the quality, which limits the generalizability of our results. Therefore, our study primarily focuses on the perspective of who are more willing to review interdisciplinary research. Secondly, the indicators for measuring interdisciplinarity of research base on journals’ ESI categories exists limitations, and the findings will be expanded after exploring other methods to measure interdisciplinary research. Thirdly, we were unable to
collect data on the year of each review record due to the limitation of data sources from Publons, which limited our ability to further examine how interdisciplinary reviewing activity affects interdisciplinary research activity over time. Despite these limitations, our study provides valuable insights into the characteristics of interdisciplinary reviewers based on a small sample of active reviewers in Publons. Our findings offer practical recommendations for the selection of interdisciplinary reviewers in the current context.

**Open science practices**
We are unable to make our data openly available for several reasons. We obtained the data through Publons’ API from January 2022. However, Publons website was closed and all open peer review records from Publons have now been amalgamated into WoS article records, which has caused some uncertainty about how to access Publons data. Furthermore, data on Publons and Web of Science is not static and can be updated or changed by authors, which makes it difficult to obtain the exact same data used in our study. Additionally, the raw bibliometric data were collected from Clarivate Analytics. A license is required to access the Web of Science database. Therefore, the data used in this paper cannot be openly available. Given these challenges, we are unable to make our data openly available at this time. However, we remain committed to transparency in scientific research and have provided as much detail as possible about the sources and methods used in our study. We hope that this information will enable other researchers to replicate or verify our findings, even if they are not able to access the exact same data we used.

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**Author contributions**
Lin Zhang: Conceptualization, data curation, methodology, funding acquisition, and writing-review & editing; Ziyi Tu: Conceptualization, data curation, formal analysis, writing-original draft, and writing-review & editing; Yifei Yu: Conceptualization, investigation, data curation, and methodology; Yuanyuan Shang: Conceptualization, methodology, and writing-review & editing; Ying Huang: funding acquisition, and writing-review & editing.

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No competing interests.

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**References**
Amber, D. (2022). Why early-career researchers should step up to the peer-review plate. *Nature*, 602(7895), 169-171. [https://doi.org/10.1038/d41586-022-00216-1](https://doi.org/10.1038/d41586-022-00216-1)


