Cognitive Science is (largely) Psychological Science

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Abstract

Cognitive science has historically been introduced as a multidisciplinary and, sometimes, an interdisciplinary study of the mind. Recent critical views of the field have questioned the foundational core and its multidisciplinary nature by suggesting that psychology has come to dominate cognitive science. As these are actively debated issues, we need further investigations. This study examines the degree of overlap between cognitive science and psychological science by comparing article keywords and departmental affiliations of authors extracted from flagship journals over the past decade (2012-2022). The results reveal that over 50% of published authors stem from psychology departments. The topics of study between the two remain quite similar as well. However, network analyses found fragmentation in terms of the methodological approaches and a considerable focus by the community of cognitive scientists on formal modeling. Based on the topics and socio-institutional analysis, we suggest that cognitive science is largely (cognitive) psychology. Implications for the field of cognitive science and its claims of multidisciplinarity are discussed.

Keywords: Cognitive Science; Trends in cognitive science; Bibliometric Analysis; Socio-Institutional Analysis; Network Analysis; Multidisciplinary; Psychological science

Introduction

Cognitive science is generally introduced as a multidisciplinary and interdisciplinary science of the mind. The *Stanford Encyclopedia of Philosophy* provides the following definition: "Cognitive Science is the interdisciplinary study of mind and intelligence, embracing philosophy, psychology, artificial intelligence, neuroscience, linguistics, and anthropology" (Thagard, 2005). In one of the first reports by the Sloan Foundation in 1978, cognitive science was posed as an amalgamation of philosophy, psychology, linguistics, anthropology, neuroscience, and artificial intelligence. This was depicted by the now famous hexagon with solid and dashed lines indicating close and distant interfaces between the different disciplines (Gardner, 1987), thus suggesting a seeming integration. The only disciplines that had solid lines connecting to the other disciplines were Psychology and Linguistics. Building on the emergence of a seemingly new multidisciplinary approach, the Cognitive Science Society (CSS) started in 1979 with a mission to bring together researchers to understand the nature of the human mind. The society has been one of the leading platforms for publishing scholarly work and has seen a consistent rise in the number of submissions. The other goal is to foster the 'discipline of cognitive science' as a supposedly singular integrated field of study comprising Artificial Intelligence, Linguistics, Anthropology, Psychology, Neuroscience, Philosophy, and Education (*Cognitive Science Society*, 2023). When the society started, psychology, artificial intelligence, and linguistics formed the core group, while philosophy, neuroscience, and anthropology played more minor roles (Gentner, 2010).

This was perhaps further strengthened by the people who formed the society and started the journal 'Cognitive Science' as the society's flagship journal—all from artificial intelligence and psychology and one from linguistics. These priorities grew from the 1960s with the rise of the cognitive turn in the United States and major European psychologists. Thus, psychology was a core part of cognitive science at its inception, but not the only one.

Researchers and influential figures have been reflective on the content and course of the discipline (e.g., Miller, 2003; Núñez et al., 2019 and a special issue in *Topics in Cognitive Science* Vol. 11(4)). Some critics have suggested that cognitive science has not become a robust interdisciplinary field or a discipline with its own set of assumptions, theory, and methodological identity and hence has failed one of the goals of forming a field of study (in the singular) (Núñez et al., 2019), others show that interdisciplinarity has grown (Alasehir & Acarturk, 2022; Contreras Kallens, Dale, & Christiansen, 2022). We confine ourselves to multidisciplinarity in cognitive science (Von Eckardt, 2001; Cooper, 2019; Schunn, Crowley, & Okada, 1998) because, unlike interdisciplinarity, the Cognitive Science journal had explicitly started with — and continues to use — the subtitle "A Multidisciplinary Journal", making the question of multiple disciplines important. There are at least two ways to think about multidisciplinarity, according to von Eckardt (2001), a local characteristic where individual works or scientists are multidisciplinary or a global characteristic where multiple disciplines contribute to the field. For both views, analyzing the relationship between a multidisciplinary field (Cognitive Science) and one of its constituent disciplines (say, Psychology) is imperative.

Our focus is on the relationship between cognitive science and psychology (used interchangeably with psychological science), which, in principle, is one out of the six or seven other constituent disciplines. Núñez et al. (2019) suggest that (a) the field of cognitive science has failed because it has not been able to arrive at a cohesive, coherent core and (b) that cognitive science is being subsumed within psychology. They analyzed departmental affiliations of authors who have

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published in cognitive science and concluded that psychology departments were disproportionately represented. This is largely in line with the start of such a debate by (Schunn et al., 1998), who had found that about 35% of affiliations in papers submitted to *Cognitive Science* were from departments of Psychology followed closely by Computer science departments at about 25%. The citations to research in psychology were the largest at about 40% from the 1970s to 1990s. (Gentner, 2010) made a similar point by analyzing the articles published in the first two issues of the journal *Cognitive Science* that year and showed that about 25% submissions were from psychology in 1978, which doubled in 3 decades to 50% in 2008 and suggested an explosion by 2038 where almost 100% could be from psychology if the rate continued.

Cooper's (2019) analysis of author-nominated disciplines in submissions to *Cognitive Science* revealed that psychology was the most frequently selected discipline, accounting for approximately 78% of submissions from 2002-2008 and 70% from 2015-2019[1]. Based on these findings, Cooper proposed that cognitive psychology is evolving into cognitive science, primarily due to its growing significance within psychological science and the reciprocal influence of psychology's shared assumptions, theories, and methodologies on cognitive science. Psychology had indeed become more cognitive, likely due to the nature of the evolution of the disciplines. Engelen (2023) found support for the standard narrative of the cognitive revolution in the 1960s using cocitation network analysis across multiple journals. They discovered that the key researchers driving the "revolution" had already become a sizeable cluster in the overall space of the then-dominant behaviorist tradition. By the late 1970s, cognitivism had largely supplanted behaviorism within psychology, as evidenced by a decrease in citations to the latter. Both instances suggest the potential for one field to diffuse into another.

A general sense from these prior findings is that there is an apparent and considerable overlap between psychology and cognitive science, but systematic comparison has been lacking. This motivated us towards another plausible conclusion that Cognitive Science *is* largely Psychological Science. One way to examine this proposition is through systematically comparing research in cognitive science with psychology. We use a data-driven approach to find the overlap in topics and trends from flagship academic outlets in 'cognitive science' and 'psychology.' In addition, we perform socio-institutional analysis to examine two aspects by building on the previous studies (Núñez et al., 2019). One, if the over-representation of psychology departments continues to persist, given the proliferation of new cognitive science departments and programs. And two, examine the patterns of departmental representation across journals of 'cognitive science' and 'psychology.'

[1]Cooper (2019) used submission data from *Cognitive Science*, while Núñez et al. (2019) and the present study relied on author affiliation data, resulting in a lower estimate.

Method

We conduct socio-institutional and bibliometric analyses focused on the last decade (2012-2022) of two major flagship journals in cognitive science that were initiated at the start of the discipline (Miller, 2003) — *Cognitive Science* and *Cognition*, and also on the *Conference proceedings of the Cognitive Science Society* that increased the ambit of the analysis significantly, allowing a more comprehensive look into the field. We contrast with articles published in the journal *Psychological Science*, which is the flagship journal of the Association for Psychological Science (APS), and *Journal of Experimental Psychology: General* (JEP:G), the key journal of the American Psychological Association (APA). We chose these outlets as they are representative of their respective disciplines. APS and APA are the largest psychological associations, while CSS is the largest cognitive science association in the world. This helped us to compare 'cognitive science' and 'psychology directly.'

Data collection and preparation

We used the Scopus database to obtain data for all the publications of interest for the period between 2012-2022. For analysis, we retained only articles and reviews while excluding all other forms of published content, such as editorials. The resultant data from cognitive science outlets yielded 9386 entries, while there were 3410 articles from *Psychological Science* and *JEP:G* for the same period.

For the keywords that help us analyze overlapping topics and trends, we retained only the first five keywords of any article (so that articles with many keywords do not bias the analysis). We then filtered for words with both singular and plural versions of existing words and, if found, replaced them with the latter ones. Equivalent words were merged (for example, keywords such as "CRT" and "cognitive reflection" were replaced with "cognitive reflection"). Additionally, keywords were grounded into category words (for example, emotions and affect were grouped in affect). This ensured that variations of the same core concept were not treated as separate keywords.

Data was also cleaned for departmental affiliations. First, we obtained departmental data from listed affiliations. The affiliations generally contained the department, institution, and the country. The extraction was done using regex. We filtered for words such as "Department", "Center", and "School" to extract departments from the listed affiliation. We then collapsed equivalent departments (for example, *Department of Psychology* and *Department of Psychological Science*s were grouped into Department of Psychology). We attempted to group departments into broad categories. This meant that all departments that, among other terms, had "Computer", "Artificial", and "Data" were categorized into "Computer Science". However, we retained distinctions such as the 'Department of Psychological and Brain Sciences' for constituent disciplines as it is not equivalent to the 'Department of Psychology.' Departments with the word "Cognitive"

or its variations, along with other terms such as "Brain" were put into the "Multidisciplinary and Cognitive Science" category. This meant that we were conservative in counting the departments of the constituent disciplines, as this process assigned all departments with any other disciplines to the last category. While this process with the keywords and the affiliations required some manual intervention due to the varieties of names of academic units, the resultant data was cleaner. All data analysis was done using R (R Core Team, 2023).

Data analysis

For the keywords, the first analysis was a simple frequency table listing the top 10 words of each journal. The second was a more complex analysis, which involved generating a co-occurrence network of keywords for each journal, enabling us to understand how the topics are related to each other. To construct the network, we first computed co-occurrences between each of the keywords, and a matrix was created with the cross-product. The resulting dataset was used to create a network graph, calculate summary statistics, and then plotted using *igraph* (Csárdi et al., 2023) and *ggraph* (Pedersen, 2022) packages.

For the socio-institutional analysis, the aggregate percentages of authors from psychology departments were calculated as a percentage of all departments. The authors' affiliation data was pre-processed and cleaned. To visualize the trends of departmental contributions over the years, we used the *ggplot2* (Wickham, 2016) package. We used two visualizations to understand the representation of various departments. For Figure 1, we calculated the proportion of researchers from psychology departments for each journal. The resulting data was merged and plotted. For Figure 2, we used the cleaned data to plot the departmental affiliations of researchers who published in *Cognitive Science* and *PCSS*.

Results

Socio-Institutional Analysis

Our results show that Departments of Psychology continue to dominate the study of cognition. In the cognitive science journals, aggregating across the journals and the years, we found that researchers from psychology departments were the first authors for 57% of the articles. The number is slightly lower for PCSS, with 50% of all first authors being from Psychology departments. Notably, this is similar to 59% of first authors in *Psychological Science* being from psychology departments. A Chi-Square test revealed that this difference is insignificant ($\chi^2 = 99$, $p = 0.24$). To test for any effect of the first and non-first authors, we repeated the analysis for the first authors only and when considering all the authors. The results stayed similar. Figure 1 shows the percentage of psychology researchers published in the venues we considered.

To more closely examine the distribution of researchers contributing to cognitive science, we examined the departmental affiliations of the first authors of *Cognitive Science* and *PCSS*. We see a similar trend of over-representation of

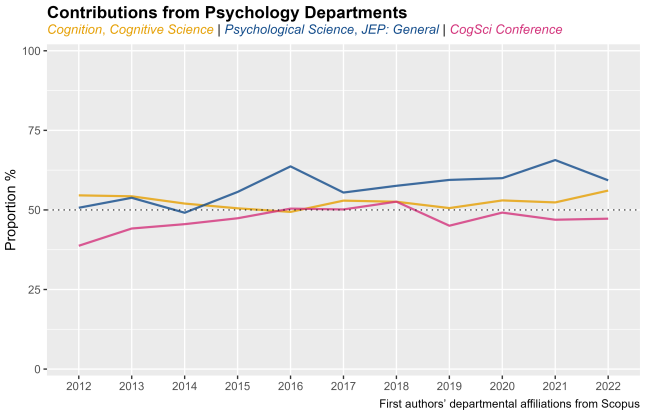

Figure 1: Proportion of researchers from psychology departments were similar across journals

psychology. Figure 2 shows the proportion of the founding disciplines contrasted against psychology. While computer science and linguistics were around 10% of total publications each, the status of the other disciplines—especially anthropology and education—seem especially dire. At times, there have been no publications from department affiliations of the other disciplines. In 2022, for example, more than 70% of the publications are by researchers from psychology, computer science, and linguistics departments. We refrain from statistical tests as the magnitude of the difference is clear. Overall, it is apparent that across both cognitive science and psychology outlets, the majority of work being published is from authors affiliated with the departments of psychology.

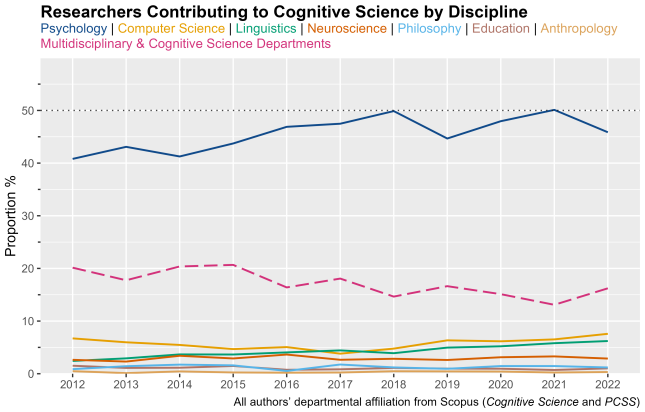

Figure 2: Contributions across academic departments

Bibliometric analysis

Keyword analysis suggests a great overlap between the topics studied by cognitive science and psychology (see Table 1 for the top ten keywords across the outlets).

When comparing the lists of keywords used in psychology (Table 1b) versus cognitive science (Table 1a) journals, only two words remain distinct after accounting for overlap between the fields: "motivation" and "learning" emerge when

Table 1: Most frequently occurring keywords (2012-2022)

(a) *Cognitive Science* and *Cognition*

Word	N	%
eye tracking	195	1.17
affect	128	0.77
cognitive development	119	0.71
attention	105	0.63
social cognition	101	0.61
computational modelling	95	0.57
decision making	85	0.51
language acquisition	84	0.50
memory	84	0.50
individual differences	80	0.48

(b) *Psychological Science* and *JEP:G*

Word	N	%
affect	380	2.63
decision making	233	1.62
attention	155	1.07
social cognition	138	0.96
memory	130	0.90
individual differences	113	0.78
eye tracking	108	0.75
cognitive development	93	0.65
motivation	89	0.62
learning	79	0.55

(c) Proceedings of CSS

Word	N	%
decision making	265	1.11
computational modelling	257	1.07
eye tracking	243	1.01
learning	207	0.86
cognitive development	192	0.80
affect	173	0.72
bayesian modelling	143	0.60
language acquisition	138	0.58
attention	135	0.56
social dilemmas	130	0.54

removing cognitive science terms found in psychology, while "computational modeling" and "language acquisition" surface as unique keywords in cognitive science. In other words, the topics of study are largely shared between cognitive science and psychology, suggesting that flagship publications in each area concentrate on investigating substantially similar phenomena. When the Proceedings (Table 1c) are considered, the distinction primarily appears to be methodological only —with a greater emphasis on constructing formal learning and information processing models or tools like eye-tracking. However, at a topic level, there is considerable similarity around mutual lines of inquiry.

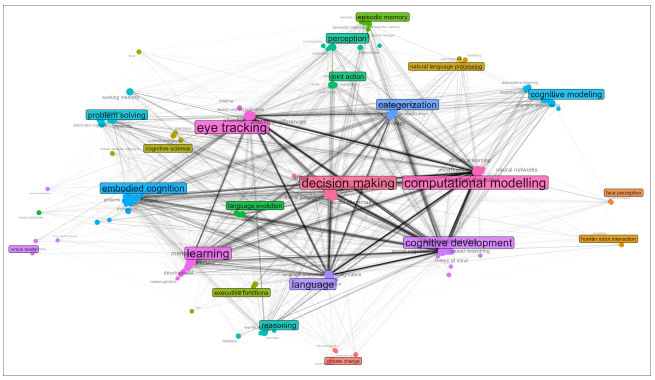

Figure 3: Keyword co-occurrence network of *PCSS*

Keyword co-occurrence networks

We conducted a more sophisticated analysis of the keywords to explore the commonalities between the various outlets further and understand the differences between our results and previous research that has found greater interdisciplinarity in the field. While the frequency of keywords allows one to understand the broad outlines of the field, it does not capture how the various topics are interlinked. This is particularly pertinent in cognitive science journals and PCSS, where the methodological approaches (for e.g., computational modeling) were among the most frequent keywords.

To circumvent this, we calculated the co-occurrence networks of the keywords. Co-occurrence networks, at their core, measure how often two entities are used together. It can be used as a base to build more complex networks that can uncover relationships among the topics.

At a basic level, the entities in a network are also clustered into "neighborhoods" based on the distance between the nodes. The nodes are connected via edges, the thickness of which denotes its weight (number of connections). The top nodes are highlighted through the node size (and the text label) when plotted. Additionally, the more central the node is in the plot, the more important it is to the network.

Plotting the networks allows us to glean any differences between the fields intuitively. In Figure 4, we see diverse topics such as motivation and power in psychology. It can also be seen that topics of many crucial areas, such as abnormal psychology, are largely absent in the generalist journals. The central nodes seem similar to some of the nodes in Figure 3, i.e., individual differences and decision making. However, we can also see the importance of keywords denoting methods in Figures 3 and 4.

The common nodes across the figures represent the fact that these fields are studying the same underlying processes. However, through the network plots of cognitive science journals, it is apparent that the methodological aspects are more emphasized in the keywords than in the psychology journals. This emphasis is on both the data collection methods, such as eye tracking and ERP, and the analysis of it through computational modeling. The example of 'attention,' a rich study area in both fields, is illustrative. We can notice that the term is present in Figures 4 and 5. However, in the cognitive science journals, there is more focus on eye tracking, with the term assigned as the label to that cluster. While the term is present in Figure 4, it is a smaller node in the cluster of attention. The networks also reveal the links between psychology and non-psychology topics. In Figure 5, we can see deep connections between language production and eye tracking. Similarly, we can see links between embodied cognition and other core topics in Figure 3 extending to keywords such as virtual reality.

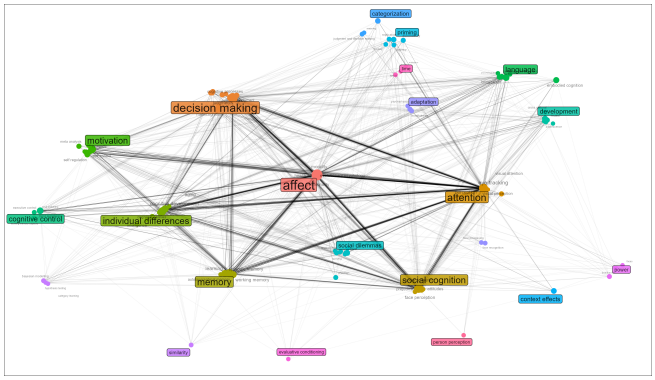

Figure 4: Keyword co-occurrence network of *Psychological Science* and *JEP: General*

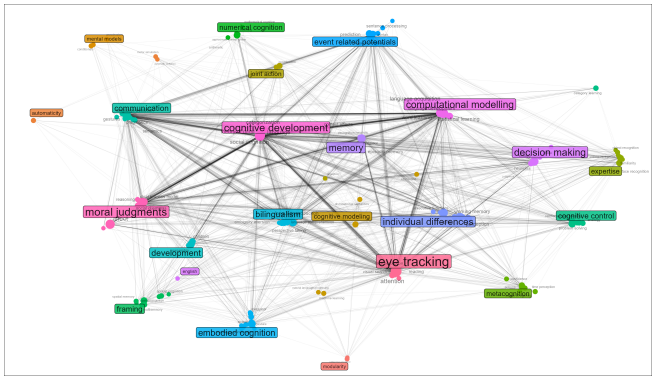

Figure 5: Keyword co-occurrence network of *Cognitive Science* and *Cognition*

The properties of the networks also allow us to understand how researchers across cognitive science and psychology study similar topics differently. Table 2 shows some basic properties of the three networks examined.

Table 2: Basic network characteristics

Network	Nodes	Edges	Density	Avg.Deg	Dia
CS&Cgn	6850	27784	0.0011	8.11	9
PS&JEP	5695	23223	0.0014	8.16	9
PCSS	8790	35783	0.0009	8.14	10

We can see that PCSS has the most nodes, 8790 keywords, while *Psychological Science* and *JEP:G* combined used a smaller set of 5695 keywords, reflecting the difference in the number of publications. The average degree is comparable across the three networks, around 8 links per node. This shows that the keywords have similar average co-occurrence pairings despite the varying network sizes. By examining the diameter—which measures the maximum distance between any two nodes—we can see that despite the variation in size, any keyword can be reached in approximately 9-10 steps within the networks.

Among these characteristics, density reveals some interesting differences. The density of the network denotes the interconnectivity of the networks. *Psychological Science* and *JEP:G* network has the highest density, indicating that keywords are broadly associated with one another, which could signal closer associations within a field. This could indicate that there are conceptual links between the topics. In contrast, PCSS has noticeably lower density. This likely reflects that the conference concentrates more on particular sub-domains, methods, and disciplines than wider multidisciplinary spaces.

Discussion

The current study uses bibliometric and socio-institutional analysis to analyze the overlap between cognitive science and psychology. We find a profound over-representation of psychologists in cognitive science and a similar proportion of researchers from psychology departments in top academic outlets both for cognitive science and psychological science. This naturally extends to scientific bodies as well. The executive board of the Cognitive Science Society, as of 2024, has a disproportionate (12 out of 16) number of 'cognitive scientists' affiliated with psychology departments and do psychological science, seen broadly. A network approach revealed persistent fragmentation in the discipline, still differentiating concepts and their interrelationships. This finding is noteworthy because when the journal *Cognitive Science* was established, the founding Editor-in-chief stated, "Current journals are fragmented along old disciplinary lines, so there is no common place for workers who approach these problems from different disciplines to talk to each other" (Collins, 1977, p. 1). After more than five decades, there seems to be little difference and much overlap between a disciplinary and a multidisciplinary journal. This is at odds with the promise of a multidisciplinary field or the goal of having researchers from seven disciplines contribute to cognitive science. Despite the growth of multidisciplinarity in emerging academic outlets that bring disciplines together (e.g., neuroscience and psychology, neuroscience and philosophy, psychology and language, linguistics and computer science) (Von Eckardt, 2001), discipline-specific trends continue to persist in submissions to cognitive science journals and conferences. This could be due to a much larger number of psychology departments than cognitive science departments or multidisciplinary centers.

One might argue that although more psychologists do cognitive science, the kind of topics studied or methods used are different. This led us to analyze the keywords and relations between them by picking broad psychology journals and not specifically cognitive psychology journals. We found an extensive overlap to suggest similar aspects of the mind being studied in the top journals within the "field" of 'Cognitive Science' and 'Psychological Science.' The only difference stems from methodology, with more computational work published in cognitive science outlets. The larger representation of modeling in cognitive science is a welcome direction, forging back to the origins when artificial intelligence

and psychology were close together with the hope of learning from each other. Computer models remain an important pillar in explicating the possible cognitive mechanisms that are not obvious in experimental research and, hence, move toward formal theorizations about the mind that have been largely missing in psychology. Synthesizing and analyzing minds seem to have been preserved, although much of the artificial intelligence research has gone on to find its own conferences and venues.

It is important to realize that the fields are dynamically changing and adapting. Psychological science, for example, has seen massive growth and diversification, now encompassing cognitive processes, mathematical psychology, computational social sciences, cognitive neuroscience, developmental psychology, and behavioral neuroscience, among other subfields—across the APA's 56 divisions. This trend shows no signs of slowing down. Cognitive science is now listed within the APA as part of division 3, covering experimental psychology and cognitive science. Perhaps these realizations are bringing psychology close to cognitive science with major general publication outlets like *Proceedings of the National Academy of Sciences* (PNAS) of the National Academy of Sciences (NAS) putting them together in one division called 'Psychological and Cognitive Sciences.'

Our conclusions have some obvious limitations. While this bibliometric approach is useful in understanding the overlay of the field, one could argue against the utility of the socio-institutional approach. As one of the reviewers pointed out, there are notable cognitive scientists outside of these selected departments, and these types of analyses have a danger of excluding their work from the ambit of cognitive science. While this is possible, cognitive scientists would largely want to publish in outlets read by peers; hence, this is likely not a big concern. Relatedly, our findings highlight the continued disproportionate quantum of work from psychology and the need for disciplinary diversity. As Bender (2022, p. 7) points out, "the mere glut of output from the dominant discipline(s) threatens to eclipse the range of what else is on offer, if only by exhausting receptive capacities". We also considered multidisciplinary departments, as this skewness could be driven by the smaller number of cognitive science departments. Even if these are considered, psychology's share remains dominant. Another reviewer highlighted that the journal characteristics, such as the impact factor, could drive submissions to psychological science journals and more general-purpose high-impact journals or even to specific targetted journals depending on author preferences. This is indeed a shortcoming. Yet another potential factor is the differing publication traditions across the disciplines, which might bias what is accepted as 'cognitive science' and 'psychology.' Furthermore, we do not discuss language and linguistics in detail although language processing can be seen from different disciplinary vantage points (psychology, linguistics, neuroscience). Finally, given the broad spectrum of psychology, many other areas (like social psychology, positive psychology, media psychology, and others) might have little in common with cognitive science. Nevertheless, none of these limitations contradict our conclusions.

An obvious question is, what should the future trajectory look like? One approach could be to course-correct and invite researchers from other disciplines to the field. This could be achieved through representation on the board and in society, as well as through academic output. A welcome direction by the CSS is the introduction of the 'Disciplinary Diversity and Integration Award' in the annual conference to boost interdisciplinarity and multidisciplinarity either at an individual level or through collaborations. The other path could be accepting the apparent merger of cognitive science and (cognitive) psychology, including research that takes in the social and cultural contexts on the one hand and the neurological substrates on the other, encompassing both topics and methodologies.

The scientific study of the mind can be undertaken at different levels of analysis and methodologies within cognitive science, which, as it stands in the 2020s, is largely psychological science. Our conclusion is supported by the over-representation of psychology in cognitive science (in line with Cooper, 2019; Núñez et al., 2019) but goes beyond by showing the commonality in both disciplines. We resonate with (Núñez et al., 2020) despite the evolving nature of the fields and others like Gentner (2019, p. 885) who has been concerned about this for a long time and says, "Pluralism is not a threat to the future of the field, but dominance by one field is" and (2019, p. 902), who says, "there is strength and resilience in the diverse perspectives and methods that cognitive science assembles together. This interdisciplinary enterprise is fragile and perhaps inherently unstable, as the looming absorption of cognitive science into psychology shows". This debate would likely continue in the future, with some suggesting that although cognitive science has converged in many ways with cognitive psychology, it still maintains an independent, interdisciplinary nature (Rosenbloom & Forbus, 2019).

We believe that the overlap with psychology and the potential merging of cognitive science is largely a given. One should not be apologetic about it since psychology, among all the six disciplines, overlaps the most in aims, goals, and subject of inquiry with cognitive science. Cognitive science has also fed back to psychology, which has grown to encompass newer methodologies and directions. Hence, the primary goal of the larger community is served, in any case—to understand the nature of the human (and possibly other) minds along with the cognitive processes using different levels of analysis, methods, participant pools, concepts, theories, and meta-theoretical assumptions.

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