1 Introduction

1.1 This Element: Its Focus and Aims

At first sight, readers approaching this Element might ask themselves whether this is (yet) another corpus-based study on disciplinary variation in written academic discourse. Such a reaction might seem logical, indeed, due to the vast number of corpus-based investigations published in the last decades aimed at analyzing linguistic aspects that reflect disciplinary differences across genres, proficiency levels, or background languages and cultures. The answer, in fact, is affirmative in two ways. In the first place, this Element does report the results of a corpus-based study. In the second, this Element does refer to the analysis of written academic discourse. The third aspect of the question, however, might not have a completely affirmative answer: this Element is not entirely concerned with disciplinary variation – or, at least, not in the way such a topic has been traditionally addressed. Defined by dictionaries as "between," "among," "in the midst of," "mutually," "reciprocally," or "together," the prefix *inter-* invites reflection on how we understand academic disciplines and disciplinary knowledge. Interdisciplinarity, as defined by Graff (2015a, para. 4), focuses on "the development and application of conceptualizations, theories, sources and methods" drawn from different disciplines and aims at their integration so as to develop new approaches and solve problems in new ways.

As pointed out by Thompson and Hunston (2020), most corpus-based research on disciplinary variation has regarded disciplines as discrete, unproblematic entities. This has been so, most probably, due to the convenience of such a view for the comparative nature of those studies. This Element also takes a comparative approach; however, it rests on an understanding of academic disciplines that challenges the idea of disciplinary homogeneity and the existence of fixed disciplinary boundaries. Going back to address the initial question, this Element is focused on exploring interdisciplinarity in academic written discourse by providing readers with an understanding of the ways in which academic disciplines interact when forming interdisciplinary fields and how language reflects (and is reflected by) these interactions.

Research on the topic of interdisciplinarity is abundant. In fact, Graff (2015b) reports that between 300 and 400 articles on the subject are published each year. However, despite such efforts to understand interdisciplinarity, several conflicts and contradictions are still present. Most of them are rooted in what Graff (2015b, p. 10) has called "myths of interdisciplinarity." One of these myths is often present in studies that "reveal expectations of similarity among interdisciplines" (Graff, 2015b, p. 11). In other words, such studies are based on the myth that interdisciplines are all similar to each other. Those assumptions

interfere with the need to offer comparisons of interdisciplines from diverse disciplinary clusters. Consequently, they also lead to incomplete examinations or overgeneralizations without providing sufficient evidence. Graff (2015b) further argues that more case studies and comparative studies are needed in order to demystify such assumptions. From a similar perspective, Fuchsman (2012) claims that interdisciplines are still understudied, and he also calls for more studies that serve to identify similarities and differences among interdisciplines.

In an attempt to fill this gap, the main aim of this corpus-based case study is to explore the language of research articles (RAs) from three different interdisciplinary fields: Educational Neuroscience (EN), Economic History (EH), and Science and Technology Studies (STS). These interdisciplines have originated from completely different disciplinary clusters: neuroscience and education in the first case, economics and history in the second one, and ethics, biomedicine, and computer engineering in the third one. A second, related aim is to compare interdisciplinary with monodisciplinary writing in an attempt to find out if typical language features of interdisciplinary writing can be identified as well as to study the degree of influence from one or the other single-domain fields over each interdiscipline. In order to reach this second aim, the monodisciplines that interact in each case will be analyzed in comparison with each corresponding interdiscipline. The work reported in this Element is focused on the use of bibliographical citations. The reasons for this choice, as well as other theoretical and methodological aspects, will be discussed in the sections that follow so as to provide the general background for this study.

1.2 Why Interdisciplinarity?

Interdisciplinarity is a ubiquitous term in current academic and educational settings, and it is rapidly becoming a dominant form of scholarly work (Graff, 2015b; Barry and Born, 2013). This scenario, however, has generated a heated debate about what is meant by interdisciplinarity. In order to shed some light, I will start by clarifying the understanding of interdisciplinarity in this Element.

According to Graff (2015b, p. 5), interdisciplinarity "is part of the historical making and ongoing reshaping of modern disciplines." Interdisciplinarity is inseparable from disciplinarity but not oppositional to it. In other words, disciplinary and interdisciplinary work are inextricably linked and mutually dependent (Graff, 2015a). As stated before, interdisciplinarity is defined and constructed by several problems and questions as well as by the means to answer those questions in different and also in new ways. This emphasis on

solving problems is often linked to the contemporary pressures and threats encountered in the real world. (Graff, 2015b).

Another important point of agreement among theoreticians is the fact that there is "no single path to interdisciplinarity, no single model, no single standard for successful development" (Graff, 2015b, p. 5). In these terms, interdisciplinarity must be understood "less as a unity and more as a field of differences," as argued by Barry and Born (2013, p. 15). A final consideration is that interdisciplinarity not only consists of the integration of various kinds of disciplinary knowledge but also comprises "the challenges surrounding effective communication to different audiences" (Frodeman et al., 2017, p. 38). In sum, this work is underpinned by an idea of interdisciplinarity as a historical construct aimed at addressing questions and problems that have consequences in the real world. In addition, the idea of *difference* is a central one: there are different types of interdisciplinarity and different types of audiences.

1.2.1 Understanding Disciplinarity in the Context of Interdisciplinarity

To grasp the true essence of interdisciplinarity, a definition of *academic discipline* that is suitable for such understanding should be proposed. This conception of discipline, as stated before, needs to challenge the idea of disciplinary homogeneity. On top of that, it also needs to challenge the existence of fixed disciplinary boundaries as a rigid notion and to leave some room for their crossing. The definition provided by Trowler et al. (2012), which is built on a social practice perspective, might constitute an adequate starting point. According to the authors, disciplines are:

> Reservoirs of knowledge resources shaping regularized behavioral practices, sets of discourses, ways of thinking, procedures, emotional responses and motivations. These provide structured dispositions for disciplinary practitioners who reshape them in different practice clusters into localized repertoires. While alternative recurrent practices may be in competition within a single discipline, there is common background knowledge about key figures, conflicts and achievements. Disciplines take organizational form, have internal hierarchies and bestow power differentially, conferring advantage and disadvantage. (Trowler et al., 2012, p. 9)

The most noticeable merit of this definition is that, as acknowledged by its authors, it "allows for the division and conflict we see within most disciplines, but also recognizes that there is a degree of commonality" (Trowler et al., 2012, p. 9). Moreover, the fact that disciplines might vary according to context is also pointed out. This definition, however, needs to be complemented by the understanding that no clear lines or boundaries between disciplines can be drawn, as

argued by Weingart and Sterhr (2000, p. xi): "The organizational matrix of disciplines is beginning to dissolve [. . .]. Disciplinary interests, boundaries, and constraints are dissolving and disciplines are merging in areas where their overlap forms a new field."

This image of more blurred disciplinary boundaries is rooted in a series of spatial metaphors that have historically been applied to describe academic disciplines. In their well-known work, which has been highly influential and widely used in discourse studies of disciplinary variation, Becher and Trowler (2001), based on Biglan (1973), describe disciplines as *academic tribes* that occupy different *disciplinary territories*. The ways in which "academics engage with their subject matter" (the tribal part) are "important structural factors in the formulation of disciplinary cultures" (the territorial part) (Becher and Trowler, 2001, p. 23). The authors add the area of application to their model, and, accordingly, they propose a system of four knowledge domains: "hard-pure" (physics, chemistry, etc.), "soft-pure" (history, anthropology, etc.), "hard-applied" (medicine, engineering, etc.), and "soft-applied" (education, law, etc.) (Becher and Trowler, 2001, p. 35).

Although this *tribes-and-territories* metaphor has been extensively used, it has also been an object of sound criticism. Trowler (2012) himself argued, a decade later, that "more fluid metaphors" are required, as drawing clear lines between disciplines and using images of "fields," "boundaries," "territories," "tribes," and so on is unhelpful (Trowler, 2012, p. 11). According to his even more recent criticism towards these essentialist views of disciplines, Trowler (2013) points out that each individual discipline has no essential "core characteristics" in the sense of being "all present and identifiable at all times" (Trowler, 2013, p. 4); this is consistent with the definition of *academic discipline* provided at the beginning of this section.

Along the same lines, Manathunga and Brew (2012, p. 65) propose leaving aside "land-based" metaphors such as *territories* so as to explore disciplinarity in terms of *oceans* and to see knowledge domains in terms of *fluidity*. Similarly, Martin (2011) talks of embarking through interdisciplinary *troubled waters*. Furthermore, Manathunga and Brew (2012, p. 67) point out that although Becher and Trowler's (2001) description of academic communities as *tribes* still persists, references to *academic cultures* are becoming more common instead. This is the term Kagan (2009) uses when he skillfully describes the three cultures: the culture of the natural sciences, the culture of the social sciences, and the culture of the humanities.

As a conclusion, and leaving the controversies around essentialist taxonomies aside, the necessity of acknowledging disciplinary differences cannot be ignored. Disciplines are inherently different in terms of their subject matter,

how they conceptualize knowledge, the methods they use, and the types of results they obtain. However, because disciplines are better conceptualized as fluid entities that do not have fixed boundaries, they have more in common with oceans than with territories. This view is thus in agreement with the idea of interdisciplinarity underlying this work.

1.2.2 Forms of Interdisciplinarity

The common approach in most previous research on disciplinary variation in academic discourse has been to analyze certain language features in a selection of disciplines to be compared (Hyland, 2000; Biber et al., 2002; Charles, 2003; Silver, 2003; Groom, 2005; Harwood, 2005; Peacock, 2014; among many others). Results are then interpreted in terms of the categorization of such disciplines within available taxonomies. The rationale underlying these studies is that each domain reflects a discipline-specific academic culture based on "shared codes of conduct, sets of values and distinctive intellectual tasks" (Becher, 1981, p. 109) in line with what has been traditionally understood as *disciplinary discourse* (Becher, 1987). When linguistic features are studied in interdisciplinary fields, however, this rationale cannot be applied any longer. In this different scenario, while it is important to consider what is already known about disciplinary differences, it is even more important to understand how disciplines interact when forming heterogeneous interdisciplinary fields; that is, when new interdisciplinary fields are created and become disciplines themselves. In other words, new theoretical frameworks need to be developed based on interdisciplinary epistemological values so as to describe linguistic aspects that reflect disciplinary **interaction** rather than solely disciplinary **variation**.

Interdisciplinarity is commonly understood as a response to disciplinary structures of knowledge. This response, Welch (2011) claims, necessarily involves epistemology, since disciplines not only organize knowledge but also establish norms of validation and the languages through which disciplinary investigation is conducted. In fact, one of the most noticeable contrasts between disciplinarity and interdisciplinarity is that they adopt completely different approaches regarding epistemology (Repko and Szostak, 2017). As each disciplinary perspective involves a set of epistemological attitudes towards knowing and describing reality (by answering questions such as "what can we know?" and "how can we know it?"), interdisciplinarity must necessarily respect these various epistemologies. As a result, interdisciplinarity is distinguished by its "epistemological pluralism" (Repko and Szostak, 2017, p. 21). Epistemological pluralism rejects notions of absolute truth and advocates for the ambiguity produced by conflict and difference. In this way, knowledge

emerges from the interaction of different epistemological perspectives (Repko and Szostak, 2017). Framed by its epistemological pluralism, interdisciplinarity has been described as adopting particular forms that are influenced by a number of factors, such as the nature of the disciplines involved, the extent to which they are integrated, and the relationship between them. As a result, several taxonomies have been proposed that frame different analytical models (see Klein, 2017 for a complete description).

For the purposes of this Element, a framework has been developed that focuses on the description of *contrasting types* (Klein, 2017) and distinct *modes* (Barry and Born, 2013) of interdisciplinarity. Contrasting typologies (Klein, 2017) are useful in exploring the nature of the disciplines involved and their degrees of integration when forming interdisciplines. Three contrasting pairs – that is, *bridge-building vs. restructuring, hybridization vs. borrowing,* and *critical vs. instrumental* – will be considered in Section 3 to compare monodisciplinary with interdisciplinary writing. As for the relationship between the disciplines involved, three modes of interdisciplinarity, defined as "ideal-typical arrangements of the interrelations between disciplines," will be explored: the *subordination-service*, the "integrative synthesis," and the *agonistic-antagonistic* modes (Barry and Born, 2013). These will constitute the framework for the comparison between interdisciplines in Section 4.

Finally, it is of paramount importance to point out that the interdisciplinary fields that make up the corpus of this work were chosen *a priori* because they are very different from an **epistemological** point of view, and so might be expected to represent different types and distinct modes of interdisciplinarity. However, the focus of this research is placed on demonstrating whether these fields are also different *a posteriori*, from a **linguistic** point of view.

1.2.3 Disciplines and Interdisciplinary Mixtures

As one of the main aims of this study is to compare interdisciplines, the focus is placed on exploring those in which the disciplines involved are different in nature from each other. On top of that, the three interdisciplines need to be different as regards the kind of disciplinary mixture involved.

As already stated, Educational Neuroscience (EN), Economic History (EH), and Science and Technology Studies (STS) are the three interdisciplinary fields chosen to study in this work. In the case of Educational Neuroscience, the two disciplines that make up the mixture are education (EDU) and neuroscience (NEU) (a branch of biology also called neurobiology). Education shares the culture of the *social sciences*, while neuroscience is a *natural science* (Kagan, 2009). For ease of

reference, Educational Neuroscience and its two related disciplines form Set 1. As regards Economic History, the mixture is between another *social science*, economics (ECO) in this case, and history (HIS), which is a *humanity* (Kagan, 2009). Economic History and its two related disciplines form Set 2. In the case of Science and Technology Studies, as this is an interdisciplinary field that covers a wide variety of topical subfields (Jasanoff, 2017), two different, although related, disciplines have been selected. More specifically, when biomedicine (BIO), which is defined as the branch of medical sciences that applies biological and physiological principles to clinical practice, is in contact with ethics (ETH) (a branch of philosophy), issues within the area of bioethics arise. In the same fashion, when computer engineering (ENG), defined as the branch of engineering that integrates several fields of computer science and electronics engineering, also interacts with ethics (ETH), engineering ethics topics arise. Bioethical and engineering ethics issues are only two of the several topical subfields that Science and Technology Studies encompasses. In other words, biomedicine and computer engineering, which are *technologies* or *applied sciences* (Gardner, 1995), in combination with ethics, which is another *humanity* (Kagan, 2009), merge to form two topical areas from the broader interdisciplinary field of Science and Technology Studies. This field and its three related disciplines form Set 3.

1.2.4 Interdisciplines and Their Journals

The three interdisciplines under analysis are defined in the paragraphs that follow according to descriptions provided in their journals. It is important to make it clear that a journal may be defined as *interdisciplinary* in a general sense, that is, like journals that "publish articles from across multiple disciplines," which "are often outside of one's own discipline" or which may or may not be "located within one discipline but cater to a wide array of disciplines or fields" (Afifi, 2017, p. 758). The interdisciplinary journals selected for this study, however, fit a more specific description: they are interdisciplinary in the sense that the interdisciplines they represent explicitly combine two disciplines. In other words, the existence of such journals reifies the interdisciplines as such, gives them identity, and legitimizes their knowledge as interdisciplinary autonomous fields. Once each journal has been presented, each interdiscipline is analyzed from the perspective of the modes of interdisciplinarity proposed by Barry and Born (2013) and according to the contrasting types of interdisciplinarity illustrated by Klein (2017).

Educational Neuroscience

Educational Neuroscience, as defined by Patten and Campbell (2011, p. 1), involves "syntheses of theories, methods, and techniques of the neurosciences,

as applied to and informed by educational research and practice." *Mind, Brain, & Education* and *Trends in Neuroscience and Education* are the journals selected for analysis. The journal *Mind, Brain, & Education*[1] aims at "supporting the development of a framework for new ideas to advance research efforts at the intersection of biology, brain, cognition, and education, and the practical innovations these research efforts inform." *Trends in Neuroscience and Education*[2], the other journal, proposes "to bridge the gap between the increasing basic cognitive and neuroscience understanding of learning and the application of this knowledge in educational settings."

This bridging-the-gap metaphor is inherent to the field, whose ultimate goal is to bridge education and neuroscience (Campbell, 2011). Thus, from the typologies illustrated by Klein (2017), the contrast between the *bridge-building* and the *restructuring* types is useful. Bridge-building occurs between complete and firm disciplines, while restructuring detaches parts of several disciplines to form a new coherent whole. In restructuring processes, traditional disciplinary categories are questioned and their boundaries are blurred. In bridge-building typologies, however, traditional categories of knowledge remain intact.

Educational Neuroscience can be described as sharing more aspects of the bridge-building typology than of the restructuring one, despite the continuous effort made by education and neuroscience researchers and practitioners to fill the gap between one and the other sides of the bridge. Edelenbosch et al. (2015, p. 48) interviewed neuroscientists and education professionals about their perceptions as regards this gap. They concluded that if neuroscience is to contribute to the complex and value-laden practice of education, it is time to find the "middle road between scientific rigor and the more pragmatic approach of the field of education," although they acknowledge this as a difficult process, since it cannot be expected that scientists and educators will make this radical shift overnight.

In addition, as pointed out in the *Trends in Neuroscience and Education* journal, "neuroscience is to education what biology is to medicine and physics is to architecture." This appreciation has to do more with the hierarchical division of labor that characterizes many forms of interdisciplinarity. In fact, it serves to characterize Educational Neuroscience as fitting one of the interdisciplinary modes proposed by Barry and Born (2013, p. 25): the *subordination-service* mode. According to this, one or more disciplines occupies a subordinate or service role in relation to the other disciplines involved, and "the service

[1] https://onlinelibrary.wiley.com/journal/1751228x
[2] www.journals.elsevier.com/trends-in-neuroscience-and-education

discipline(s) are typically conceived as making up for, or filling in for, an absence or lack in the other, (master) discipline(s)." In this case, education lacks the knowledge provided by neuroscience (master discipline), but neuroscience needs to be informed by education (service discipline) in order to fulfil the aims of the interdisciplinary activity.

Economic History

As stated by Shanahan (2015), it is not simple to define the boundaries of Economic History. There are multiple intersections and overlaps with other fields. For this study, the *Journal of Economic History* and the *Economic History Review* are the journals selected for analysis. In the *Journal of Economic History*[3], it is noted that Economic History "is devoted to the multidisciplinary study of history and economics, and is of interest not only to economic historians but to social and demographic historians, as well as economists in general." The second journal, the *Economic History Review*[4], aims to "keep anyone interested in economic and social history abreast of current developments in the subject." While Economic History draws extensively on its close relationships with the disciplines of economics and history, its ultimate strength lies in its broad interdisciplinary connections across a wide range of social science and business subjects. Furthermore, it encourages diverse but rigorous approaches to understand our economic past. In most cases, there is a productive "cross-fertilization" process between history and economics (Ritter and Horn, 1986, p. 439).

This cross-fertilization process helps to characterize Economic History within the contrasting types of *borrowing* vs. *hybridization* illustrated by Klein (2017). Borrowing is more typical of methodological interdisciplinarities; that is, borrowing a method or concept from another discipline to test a hypothesis, to answer a research question, or to help develop a theory (Bruun et al., 2005, p. 84). Hybridization, however, encompasses a general process of development with two stages: the first is specialization and the second is the continuous reintegration of fragments and specialties. It is clear that Economic History goes beyond the borrowing of methods and concepts from one discipline or the other. In fact, it has been described as a hybrid or "interstitial cross-discipline" (Klein, 2017, p. 27). Klein (1996, p. 192) understands interdisciplines like Economic History as "institutionalized hybrid fields" and distinguishes them from mere disciplinary exchanges that

[3] www.cambridge.org/core/journals/journal-of-economic-history
[4] https://onlinelibrary.wiley.com/journal/14680289

remain at the level of cross-disciplinary contacts and borrowing of methods and concepts.

Finally, a suitable way to understand the relationship between the disciplinary forms of knowledge that interact in Economic History is to think of them as part of a synthesis through a process of integration or negotiation, typical of an *integrative-synthesis* (Barry and Born, 2013) mode of interdisciplinarity. According to this mode, a given interdisciplinary practice "proceeds through the integration of two or more disciplines in relatively symmetrical form" (Barry and Born, 2013, p. 25): mainly economics and history in this case. In other words, interdisciplinarity is understood additively as the sum of two or more disciplinary components or as achieved through a synthesis of different disciplinary approaches, as suggested by Petts et al. (2008).

Science and Technology Studies

Science and Technology Studies is "an interdisciplinary field that investigates the institutions, practices, meanings, and outcomes of science and technology and their multiple entanglements with the world's people inhabit, their lives, and their values" (Felt et al., 2017, p. 1). More specifically, Science and Technology Studies involves two broad streams of scholarship: a focus on the nature and practices of science and technology and an emphasis on the impact, control, and risks that science and technology pose to human values (Jasanoff, 2017). This latter stream frames the scope of the selected journals: *Science, Technology, & Human Values* and *Science and Engineering Ethics*. Both publish articles about bioethical issues and the ethical dimension of engineering. As the editors of *Science, Technology, & Human Values*[5] point out, scientific advances improve our lives, but they also complicate how we live and react to the new technologies. As a result, human values come into conflict with scientific advancement. Furthermore, research that examines ethical issues that arise from the practice of science and engineering is needed in order to cope with instances of misconduct in science, as stated by the editors of the *Science and Engineering Ethics*[6] journal.

In short, Science and Technology Studies research "seeks to open up science, technology, and society to critical assessment and interrogation" (Felt et al., 2017, p. 1). For Jasanoff (2017, p. 192), this field "problematizes the notion of discipline and stresses the idea of challenging disciplinary configurations." Such a description helps to characterize this interdiscipline as a *critical* type, which contrasts with the *instrumental* type (Klein, 2017). According to Repko and Szostak (2017), instrumental interdisciplinarity is problem-driven. It is

[5] https://journals.sagepub.com/home/sth [6] https://www.springer.com/journal/11948