INTRODUCTION

The *Oxford English Dictionary* traces the etymology of “discipline” as the antithesis of “doctrine.” Discipline pertains to practice or experience in the context of disciples or scholars, whereas doctrine (the property of the doctor or teacher) is more concerned with abstract theory. In present-day academia, it is more difficult to find a consensus on the nature of disciplines. Disciplines are often considered ephemeral abstractions, coalesced around some combination of socio-cognitive, institutional, and technological entities. Basically, disciplines are the stuff of knowledge, people, and the things with which they interact. Physics, sociology, and history are probably disciplines. Cupcakes, true love, and fraternities probably are not. The jury is still out on entrepreneurship, computational linguistics, and digital humanities. The question, of course, is why.

Why are some things disciplines and others not? Where can we draw the lines to distinguish knowledge areas that are too small, too big, too disperse, or just too odd to be called disciplines? At what point does something become a discipline? Do disciplines have typical processes of maturation? These questions are not trivial, nor are their answers immediately apparent. Chemistry, classics, and biology have been re-enforced through institutional structures for quite some time—it is only in a recent global push for interdisciplinarity that the lines between these disciplines has begun to blur. The lines themselves, however, are also recent creations, part of a continuous process of coalescence and re-drawing.

Foucault first called attention to the discipline as a “system of control in the production of discourse” and “to discipline” as the larger set of strategies and techniques of control that have come to dominate much of modern life (Foucault, 1977; Shumway and Messer-Davidow, 1991). This negative view of disciplinarity is relatively new: “The various connotations of ‘discipline’ have until recently been entirely positive; to call a branch of knowledge a discipline was to imply that it was rigorous and legitimate. The name did not reveal that knowledge was produced by regulating or controlling knowledge-producers, nor that the training of disciples produced the general acceptance of disciplinary methods and truths” (Shumway and Messer-Davidow, 1991, p. 202). Modern disciplines came into being only with the division of natural philosophy into independent natural sciences at the end of the eighteenth century; according to Shumway and Messer-Davidow (1991, p. 204) the humanities “is a twentieth century term of convenience for those disciplines excluded from the natural and social sciences.” While modern philosophy was defined by what was removed from it in the creation of the sciences, the other modern humanities emerged first in the form of the classical philology, which produced history, modern
languages, and art history as descendants (Shumway and Messer-Davidow, 1991, p. 204). Jacobs (2014, p. 1) make the case that the entire “system of disciplines, departments, and majors... became a standard feature of most American colleges and universities after the Second World War.” The question remains: what criteria must be fulfilled for an area of study to be elevated to the status of discipline? How might the criteria for disciplinarity be different in the 21st century from preceding eras?

To complicate matters further, there is a bevy of associated terms that lack distinction. “Field” is often used interchangeably with “discipline” (Bordons et al., 2005, 1999; Bourdieu, 1988; Cole, 1983; Dogan, 2001; Garfield, 1979; Hargens and Felmlee, 1984; Porter et al., 2007; Whitley, 2000), although occasionally a “field” is something left undefined (Bordons et al., 2005; Rafols and Meyer, 2006; Van den Besselaar and Heimeriks, 2001) or equivalent to a “subdiscipline” (Carayol and Thi, 2005; Fry, 2006). Nascimento and Marteleto (2008) place “field” at the center of a complex structure fed by “discourse communities,” “domains,” “informational practices,” “subjects,” and so forth. Bordons et al. (2005) define “field” as the same as and not the same as a “discipline” within the same article. “Specialty” can be synonymous with “discipline” (Garfield, 1979; Hargens and Felmlee, 1984; Leydesdorff and Rafols, 2010), subordinate to “disciplines” (Dogan, 2001; Rafols and Meyer, 2010), or unrelated entirely (Rafols and Meyer, 2010). “Research areas” are something wholly undefined and separate (Morillo et al., 2003), usually more general than a discipline (Van den Besselaar and Heimeriks, 2001). “Scientific domains” and “disciplines” can be synonymous (Carayol and Thi, 2005; Leydesdorff and Rafols, 2010), although sometimes they are not (Porter et al., 2007; Rafols and Meyer, 2010). Occasionally they are “bodies of knowledge” (Rafols and Meyer, 2010). Krishnan (2009) made the distinction between “academic” and “ideal” disciplines. Sometimes there are clear hierarchies, perhaps going from “area” to “discipline” to “journal” to “paper” (Bordons et al., 2005). Notice the lack of “subdiscipline” or “field.” “Areas” are often hierarchically above “disciplines” (Bordons et al., 2005; Porter and Rafols, 2009), while Dogan (2001) places “specialties,” “sectors,” “fields,” and “subfields” subordinate to “disciplines.”

For the purpose of this article, we do not attempt to differentiate or define these terms. We point them out to present the lack of consistency not only in understandings of disciplinarity, but also in the constellation of terms related to it. Disciplines are continuously redefined, or left undefined entirely. This article surveys the many angles from which scholars view disciplinarity: from scholars studying the term specifically, to those who use it to talk about their own disciplinary histories and identities. We also look at the many ways disciplinarity has been implicitly defined in measurements of disciplinary. The scope is necessarily wider than can be exhaustively reviewed, but a complete survey is not necessary to show that even those within the same so-called disciplines are not speaking the same language, and are often unaware of their terminological differences. Many of the authors reviewed here who ostensibly have goals of transcending disciplinarity often point out how language is a key barrier to interdisciplinary research.

The complexity of disciplinarity—what constitutes a discipline and how it behaves—is highlighted and exacerbated by recent internal and external pressures to break down disciplinary walls. Disciplinarity is an issue of self-identity and self-preservation, but also one of organization, funding allocation, and impact assessment. In a world of limited resources and ever-higher stakes, academic life in general, and disciplines in particular, are in a constant battle for survival, fighting to prove their relevancy and utility. With so much political and industrial machinery stressing that interdisciplinarity is the key to staying ahead, traditional disciplines and individual scholars find they must play the game correctly if they do not want to fall behind. Unfortunately, neither the evaluatory mechanism nor those fighting for quality
evaluations have any consensus on what a discipline is, and therefore also lack adequate conceptualizations for inter-, cross-, multi-, or trans-disciplinarity.

**Objective and Approach**

The objective of this article is not to provide a prescriptive list of elements that are necessary components of disciplinarity, nor is it to recommend a measurement for identifying the birth, maturation, and interaction of disciplines. Rather, we aim to provide examples of the ways in which authors have conceptualized and operationalized disciplinarity, exploring their incongruencies and interrelations. It is also to highlight the necessity for scholars to think in a holistic way about conceptualizations and operationalizations, especially those which precede measurements and metrics.

This paper will be organized in the following manner. First, we examine how scholars have explicitly conceptualized disciplinarity, including the ways in which they list criteria for the birth or maturation of a discipline in specific ways. Typically these take the form of “a discipline is a….,” or “a discipline is comprised of…” or “a discipline has a…” These criteria were embedded in the definitions—we extracted, grouped and labeled them inductively. This is not meant to be a comprehensive list of every criterion provided in all literature, nor are we quantifying the number of criteria to identify the most common or most frequent invocations. Rather, our goal here is to be illustrative—to provide a set of categories that describes the breadth of criteria that are used in investigations of disciplinarity.

These criteria are largely derived from scholars who are attempting to study disciplinarity *per se* (most often historians, philosophers, social scientists, and sociologists of science). However, disciplinarity has also been studied implicitly by other scientists detailing the disciplinary history of their own domains. Therefore, we examine more than a dozen disciplinary histories across the range of scientific disciplines in order to identify patterns in criteria in these narratives. In this stage, we attempt to identify implied conceptualizations. That is, literature that, in telling the story of the birth of the discipline, implies the criteria necessary for disciplinization. These stories typically involve the following narrative structure: “Discipline A became a mature discipline in [date], when they started their first professional journal and began offering a doctoral program from [famous university].” In this case it is implied that starting a program and journal are criteria for disciplinization. Again, the goal here is not to be comprehensive, but to investigate a range of disciplines for illustrative purposes.

We then examine the empirical, primarily scientometric, literature to see how scholars have operationalized disciplines in quantitative studies of science. We look explicit at how disciplines are selected and measured and the criteria for disciplinarity that are implied in these measurements. For example, if an author is deemed more interdisciplinary if they publish in journals spanning several subject categories, then subject categories are implicitly representative of various disciplines. Our survey of operationalizations serves to show how implicit understandings of disciplinarity are often contradictory and orthogonal to theorized conceptualizations and definitions.

This investigation allows us to provide a discussion of the differences between conceptualizations and operationalizations of disciplinarity and the implications of these differences for studies and evaluations of science. This work is particularly critical in an age of heightened accountability, where decisions regarding the allocation of resources are often largely dependent on the discipline to which one belong and where scientometric analyses are increasingly incorporated into academic auditing processes.
CONCEPTUALIZATIONS

Scholars from a wide range of disciplinary perspectives have weighed in on conceptualizations of disciplinarity. We agree with Messer-Davidow, Shumway, and Sylvan (1993) that disciplinarity is in some ways a “problematic neologism” as it is often conflated with epistemology, sociology of knowledge and the history of ideas (p. 1). We focus here on the nature, criteria and “possibility conditions of disciplines” (Messer-Davidow et al., 1993, p. 2) and aggregate themes from scholars who have sought to explicitly define and understand what contributes to and constitutes a discipline as an entity.

Many potentially synonymous terms for the concept of a discipline exist including “epistemic cultures” (Knorr-Cetina, 1999), “invisible college” (De Solla Price and Beaver, 1966), “communities of practice” (Lave and Wenger, 1991), and “academic tribes” (Becher and Trowler, 2001). However, there exist subtle and distinct differences in each of these terms. Therefore, we sought to synthesize the literature that focused explicitly on notions of disciplines.

Cognitive. A number of conceptualizations emphasize the cognitive orientation of disciplines: that is, that there is a shared body of content, theories, and methods that define the field. This intellectual component has been described as “cognitive coherence” (Bulick, 1982, p. 12) and a “loosely identified object of knowledge” (Valenza, 2009, p. 5). Some definitions emphasize the theoretical aspect of this intellectual tradition. For example, Lattuca (2002) states that a discipline should have and “underlying theory, idealized models and analogies, and exemplars” (p. 715) and Biggs (1991) defines a discipline as having “theoretical framework and the established research methodologies and conventions of interpretations” (p. 189). Like Biggs, others have emphasized the methodological orientation, stating that disciplines have “finite set of methods of inquiry” (Valenza, 2009, p. 5) and “systematic ways of organizing and studying phenomena” (Lattuca, 2002, p. 715). Lastly, the organization of the content is another element of the cognitive criteria. For example, a discipline can be defined as “a particular way of organizing experience and information” (Holland, 2008, p. 11). Disciplines, therefore, are units of intellectual content, coherently organized.

Social. The social element is a defining criterion for many scholars, who have used phrases such as a “recognized community of researchers” (Valenza, 2009, p. 5), “group of individuals” (Bulick, 1982, p. 20), and an “organized social grouping” (Lattuca, 2002, p. 716) to define what constitutes a discipline. Geiger (2004) emphasize the social element in his definition: “A discipline is above all, a community based on inquiry and centered on competent investigators. It consists of individuals who associated in order to facilitate intercommunication and to establish some degree of authority over the standards of that inquiry” (p. 29). These definitions imply that there are no disciplines of single individuals; a discipline requires a community of multiple researchers. Or, as Lenoir wrote to counter “founder myths”: “no one creates disciplines” (Lenoir, 1997, p. 51). These definitions build upon Bourdieu, who noted that “effects produced by the structural necessity of the field can be accomplished only through personal relationships, based on the apparent contingency of socially expressed coincidences of mutual encounter and acquaintance and on the sympathies and antipathies inspired by a shared habitus” (Bourdieu, 1988, p. 2). Furthermore, to describe these communities as “recognized” (Valenza, 2009, p. 5), “organized” (Lattuca, 2002, p. 716), and “self-contained and isolated” (Braun and Schubert, 2003; Nissani, 1995), implies that these social communities are bounded, interactive, and contain normative rules and patterns of behavior. However, very few of these conceptualizations contain explicit operationalizations. The researcher is left to imagine how one might identify and discern what does and does not constitute a social grouping; that is, the minimum number of individuals or degree of cohesiveness necessary to constitute a disciplinary community.
Communicative. As Montgomery (2003) notes, “there are no boundaries, no walls, between the doing of science and the communication of it; communicating is the doing of science” (Cronin, 2005). As this quote suggests, many scholars consider communication to be a central component in the establishment and identification of disciplines. Conceptualizations of disciplinarity note that “disciplines use specific terminologies or a specific technical language adjusted to their research object” (Krishnan, 2009, p. 9) and have “symbolic forms of communication” (Lattuca, 2002, p. 715). Definitions state that disciplines must have an “established manner for communicating their findings” (Valenza, 2009, p. 6) and a “linguistic component (the symbolic language that allows elements to be identified and relationships defined and explored)” (Lattuca, 2002, p. 715). Miller and Boix-Mansilla (2004) suggest that commitment to a “discourse community” (p. 3) is one of the necessary conditions for disciplinarity. Hyland (2004) considers these practices to be paramount in defining disciplines. Hyland states that “writing is not just another aspect of what goes on in the disciplines, it is seen as producing them” (p. 3). Alternatives to this view suggest that in an age of globalization and interdisciplinarity, there are no longer recognized, coherent, and homogeneous academic discourse communities which can be used to define a discipline (Vassileva, 2008). However, disciplinary languages are often cited as one of the key obstacles to performing interdisciplinary research (Valenza, 2009, p. 28). More work, therefore, is needed to understand how disciplines are performed in terms of discourse and the way in which new or creolized languages emerge in the case of interdisciplinarity.

Separatedness. Dascal and Dutz (1996) state that being “able to call a field of studies ‘a discipline’ is important because the application of this term assigns to it a position in a system of disciplines and implies properties such as having a homogeneous domain, a specific perspective, a definite set of methods, or a consistent theory” (p. 746). In this way, the criterion of boundedness arises, in which a discipline exists only when it’s “defining elements...distinguish it from other knowledge formations” (Gunawardena et al., 2010). The body of accumulated knowledge should be “specific to [members of the discipline] and not generally shared with another discipline” (Krishnan, 2009, p. 9). As Dascal and Dutz (1996) state: “To become a discipline, a field must develop a ‘separate identity’. This requires the determination of its portion vis-à-vis other areas of knowledge and culture, involving a process of differentiation and specification of the field, paralleled by efforts to unify and homogenize what was previously dispersed among other fields” (p 748). The labeling or naming of the discipline becomes an important element in this identity formation (Valenza, 2009), giving the discipline clear distinction in the academic marketplace (Tedre, 2011).

Tradition. Many definitions point to historical tradition and the element of time passing (i.e., maturation) in order for something to be recognized as a discipline. Dascal and Dutz (1996) invoke the concept of continuity to differentiate between a passing trend and an established discipline. Other definitions state that a discipline must have a “generally accepted intellectual tradition” (Valenza, 2009, p. 5) or a “mastery of a generalized cultural tradition” (Valenza, 2009, p. 6). Scholars note that the disciplines are “built on the discourse of forebears” (Lattuca, 2002, p. 716) and have a “group of institutions that persist and remain stable over time” (Valenza, 2009, p. 5). This speaks to a criterion that can be easily operationalized to describe mature disciplines, but how can one measure the component of history when evaluating emerging disciplines? This is also problematic when trying to identify a point of origin. Hence, Dascal and Dutz (1996) propose that we cannot and should not look for a point of origin in a discipline, but rather the moment when a convergence of factors happens: “there is no single moment in the process that can be pinned down as the beginning of its scientific status, or as the decisive ‘turning point’, where the ‘crucial’ n-th feature is added” (p. 748). This reinforces the dynamic nature of knowledge communities and a need to construct frameworks to describe stages of
development experienced by disciplines, specialties, and paradigms (de Mey, 1982). Such dynamism makes clear conceptualizations more difficult.

**Institutional.** The maturation of a discipline is perhaps best represented by its institutionalization, particularly in the form of academic departmentalization (Becher and Trowler, 2001, p. 41; Nyquist, 2002), systems “for perpetuating the discipline by training new practitioners” (Valenza, 2009, p. 6), and research centers (Bowker and Latour, 1987). The institution is given many responsibilities in these definitions: it is responsible for “rigorous training, supervision of conduct, and potential for censure” (Hunt, 1994, p. 2), and “validating both the adequacy of the training and the competence of trained individuals” (Valenza, 2009, p. 6) as well as “making sure such competence will be put to socially responsible uses” (Valenza, 2009, p. 6). Jacob’s (2013) definition is of a discipline entirely rests on the institutional component: “A discipline is defined as a broadly accepted field of study that is institutionalized as a degree-granting department in a large number of colleges and universities” (p. 27). Institutionalization can also come in the form of communicative genres: for example, the development of journals is listed as demonstration of stability in Valenza’s (2002) definition. The development of curricula, textbooks, and instructional communities are another manifestation of disciplinarity (Lattuca, 2002). Lenoir (1997) heavily stressed the relationship between institutionalization and disciplinarity (drawing upon Foucault):

> "Disciplines are the infrastructure of science embodied above all in university departments, professional societies, textbooks and lab manuals...the discipline helps to structure scientists relationships to particular institutional and economic contexts. Disciplines are the institutional mechanisms for regulating the market relations between consumers and producers of knowledge." (p. 46)

In these operationalizations, institutionalization imprints doctoral training and communication with a certain authority and formality, necessary for disciplinary identity.

**Combinations.** Many of the above quotes were taken out of context from the larger definitions in which they were embedded. This may be problematic in that the combination of criteria may be in itself informative. For example, composite definitions of disciplines include: a “group of researchers working on a specific set of research questions, using the same set of methods and a shared approach” (Van den Besselaar and Heimeriks, 2001, p. 2); a “self-contained and isolated domain of human experience which possesses its own community of experts, with distinctive components such as shared goals, concepts, facts, tacit skills and methodologies” (Braun and Schubert, 2003, p. 183); a “body of knowledge and a social body that generates, evaluates, communicates, and teaches the corresponding knowledge” (Schummer, 2004, p. 436); and “a field of study that has a recognized community of researchers who have in common most of the following: an agreed-upon name, a loosely identified object of knowledge, shared research goals, a finite set of methods of inquiry, a generally accepted intellectual tradition, a group of institutions that persist and remain stable over time (such as university departments and academic journals), a system for perpetuating the discipline by training new practitioners, a group of working concepts and rules for adding new rules and concepts, and an established manner for communicating their findings” (Valenza, 2009, pp. 5–6).

Other definitions describe various characteristics of a discipline. For example Lattuca (Lattuca, 2002, p. 715) described disciplines as having a number of components: a “substantive component (which includes the assumptions, variables, concepts, principles, and relationships of the discipline); the linguistic component (the symbolic language that allows elements to be identified and relationships
defined and explored); the syntactical component (the search for organizing processes around which the discipline develops); the value component (commitments about what is worth study and how it should be studied); and the conjective component (the discipline’s relation to other disciplines).” Buker (2003, pp. 74–75) remarked that “fields with departments, graduate programs, and professional associations are considered are considered disciplines. But, of course, a discipline has more intellectual integrity than this suggests... 1) A discipline has a past, a present, and a future and so confers identities on its practicing members 2) disciplines share a vocabulary with technical terms that facilitate precise communication; 3) a discipline has a set of key questions that guide inquiry 4) a discipline has a set of methods or strategies of interpretations; and 5) a discipline produces shared epistemological understandings of what counts as evidence.” Such composite definitions often do not explicitly state whether a discipline must meet all criteria listed in the definition or if meeting the majority of these criteria is enough to constitute disciplinarity. It also obscures the premise put forth by Whitley and others that criteria may vary—as Whitley argued: “it is difficult to characterize formal knowledge production as a single kind of social activity governed by a single set of norms and conventions” (Whitley, 2000, p. xli). However, the previous operationalizations imply that a discipline is characterized by a number of components—and that one of these alone is not enough to define an entity as a discipline.

NARRATIVES

Once an area of study is seen to have reached a certain point of maturation, it is fairly common for the history of the discipline to be documented in some fashion. These disciplinary histories provide implicit notions of the criteria necessary to achieve disciplinarity: the focus on certain elements demonstrates the activities that are involved in the codification and maturation of a discipline. Although some narratives are used to show that a discipline does not exist (Amariglio et al., 1993), examining a range of disciplinary histories can reveal shared characteristics that are common in defining disciplines.

The Great Man. One of the dominant criteria shared by many of the histories is a “great man” or a single published work that serves as catalyst for the discipline, e.g., Kurt Lewin and political psychology (Stone and Schaffner, 1988), Baudelaire and the literary field (Bourdieu, 1996). Some give parental attribution of their discipline to individuals who far predate the modern incarnations of the discipline: “Plato may be considered the father of political philosophy, and Aristotle the parent of political science, at least in the West” (Rodee et al., 1976, p. 4). In many cases, the Great Man produced a Great Work, for example the association between Adam Smith’s, *An Inquiry into the Nature and Causes of the Wealth of Nations*, and the beginning of Economics (Bulick, 1982); Jean Mabillon’s (1681) *De re diplomatic libri sex*, credited with the birth of Diplomatics (Guyotjeannin, 1996); Archie Cochrane’s (1972) instigation of Evidence-based Medicine with his *Effectiveness and Efficiency: Random Reflections on Health Services* (Belsey, 1997); and Frederick Seitz’s (1940) start of Solid State Physics with his *Modern Theory of Solids* (Weart, 1988). In some cases, the Great Man is drawing upon earlier works: for example, Joshua Lederberg, the Great Man of Exobiology, is said to have been inspired by Alesadr Oparin’s (1938) *The Origin of Life* (Strick, 2004); in developing State Medicine, Stokes, Paget, and Ackland were said to have drawn from Wildbore Rumsey’s (1856) *Essays in State Medicine* (Tageldin, 2010). Such theories of disciplinary origin, however, are likely to be critiqued as elitist, sexist, and overly simplistic in their lack of contextualization in the larger social space.

Societies and conferences. The second criterion that is often discussed is the proliferation from one Great Man to many, in the form of intellectual societies and conferences. As Weart (1988) described in the history of physics: “physical disciplines could not become distinct until there were thousands of
physicists in the world—enough so that each field was strong enough to stand on its own as a community of researchers” (p. 39). Some histories pinpoint the start of the discipline to the creation of a society. As Stone and Schaffner (1988, p. v) narrate: “The short history of political psychology as an organized discipline dates from 1978, when the International Society of Political Psychology (ISPP) was founded”. Similarly the Spitzer conference in Istanbul is often credited for the creation of Comparative Literature (Tageldin, 2010). In the case of solid state physics, it wasn’t the creation of a new society, but rather a formal subdivision of American Physical Society that marked the birth of the discipline (Weart, 1988). For other disciplines, it’s a corporate center: IBM’s Zurich Research Group was a hallmark social grouping for nanotechnology (McCray, 2007). Governmental support creates the social structure in still other examples: Lederberg was made head of a subpanel of the Space Sciences Board (advisory board to NASA) that brought together prominent “origin-of-life scientists” to discuss extraterrestrial life (Strick, 2004). This criterion reinforces the sociality of disciplines as emphasized in the conceptualizations discussed earlier: there are no disciplines of one.

**Governmental funding and recognition.** As implied in the previous section, governmental support is often an instigator and facilitator in the development of new disciplines. Nanotechnology was propelled by the millions of dollars pouring in from governmental agencies around the world (McCray, 2007). Federal financial support was also credited with supporting the division of subfields of physics (Weart, 1988). The origin story of computer science, as told by Tedre, emphasizes the importance of governmental recognition (2011):

> “Although the first societies for computing professionals were formed as early as 1946, although there were elaborate defenses of computer science already in the 1960s, and even though the first departments of computer science were established in the early 1960s, it took until the 1970s until the field gained stable foothold as an independent discipline. In 1974, the National Science Foundation (NSF) of the U.S. affirmed the distinction of computer science from all other science and engineering disciplines and recommended that the NSF make that distinction manifest in its programmatic activities.” (p. 362)

Other disciplines have similar turning points in achieving disciplinarity through governmental support: Lederberg achieved governmental recognition through NASA funding for Exobiology (Strick, 2004); a Royal Charter was given to Diplomatics (Guyotjeannin, 1996); and the National Health Service Research and Development Programme funded the establishment of the Cochrane Centre in Oxford, giving credibility to Evidence-based Medicine (“The History of Evidence Based Medicine,” n.d.). In the future, one might project a disciplinization of Big Data given the rise of political and government recognition of this area of research (Ekbia et al., accepted).

**Social need.** Disciplinary histories often include a justification for why the discipline emerged—a gap in knowledge, a response to cultural, political pressures, or the emergence of capabilities that were not previously possible. In such cases, it is rarely a “Great Man”, but rather a *Zeitgeist* that is credited with the development of a discipline. In chronicling the development of Women’s Studies, Buker (2003) argues that there was not a single individual, but that its development is a shared narrative of community and history. When Riedel described the birth of modern Middle Eastern Studies, he described the longstanding Western fascination with the Orient and “The Other” in the 19th century. In some cases, disciplines have multiple parallel “births” in various countries, as described by Tageldin (2010) in the history of Comparative Literature, which he describes as a response to a rising sense of nationalism in many countries. There are also specific events in history which precipitate disciplines: for
example, the rise of political psychology has been directly traced to the drafting of psychologists into the
army during World War II (Stone and Schaffner, 1988). Terrorism studies emerged in the 1960s and was
influenced simultaneously by the media and the government in the U.S. (Reid, 1997). Similar influences
have played upon the recent development of sustainability studies as a discipline (Burger et al., 2012).

**Institutional recognition.** Recognition by academic institutions, in the form of centers, departments, and
schools is another landmark in disciplinary histories. The maturation of Evidenced-based medicine is
justified by stating that the Cochrane Centre in Oxford grew to 12 centers (“The History of Evidence
Based Medicine,” n.d.). Post-graduate education in state medicine was a sign of development (Acheson,
1986). The development of tenure lines and graduate programs indicated that Women’s studies had
achieved disciplinarity (Buker, 2003). However, the use of this indicator has been critically examined by
some scholars. As Buker (2003) asked: “Is there a discipline created by the combination of history and
Political Science, or is this merely an administrative convenience used by some universities? Do
administrative conveniences alter intellectual practices?” (p. 74). This is especially poignant in the era of
mass reorganizations and mergers on academic campuses, as administrators seek to brand and name
schools in order to achieve administrative efficiency.

**Publications.** One legitimizing agent is the documentation of knowledge in standard forms. For example,
socializing histories “appear in the first chapters of standard text books” (Graham et al., 1983; Shumway
and Messer-Davidow, 1991, p. 218) and are intended to “introduce students to a discipline by
presenting biographies of its greater practitioners and accounts of landmark advances” (Shumway and
Messer-Davidow, 1991, p. 218). The establishment of journals represents another landmark activity in
the emergence of a discipline: the official “birthdate” of Developmental Biology is associated with the
founding of the *Journal of Evolutionary Biology* (Raff et al., 1999). Similar patterns can be observed in
other disciplines—as Strick (2004) explained, journals are one of the “trappings usually thought
necessary for a scientific discipline” (p. 139). This is emphatic in the identity of Sociology as it related to
the *American Journal of Sociology* (AJS)—as Abbott (1999) explained, “there was no discipline of which
the AJS was the journal. Quite the reverse. The AJS, with a few other institutions and networks, created
the discipline” (p. 87). In some ways, the unit of analysis is even smaller than a journal. In telling the
history of bioinformatics, Ouzounis and Valencia (2003) list “twenty publications that influenced our
view of bioinformatics” (2003, p. 2187). These remarks echo the centrality of communication raised in
the explicit definitions of disciplinarity.

**Relationships to other disciplines.** In the conceptualizations of disciplinarity, a common theme was
separatedness of disciplines, what might be referred to as “colligation” (Abbott, 1999, p. 29) or the
“process of differentiation” (Messer-Davidow et al., 1993, p. 2). However, in studying disciplinary
histories, emphasis was frequently placed on the relationship with other disciplines. As Weart (1988)
elegantly described: “When we speak of the emergence of solid state physics...we do not mean the
creation of something *de novo*. We mean a grand rearrangement of an entire array of specialties, old
and new, into a novel constellation” (p. 38). He describes this as occurring within the process of
scientific specialization—called “twigging” by other scholars (Benjamin, 1974). Some definitions
reference the fact that an area bridged or “tested the borders” between two disciplines (Guyotjeannin,
1996). Other stories are those of “mergers” of a few disciplines (Gilbert, 2003; Raff et al., 1999; Tedre,
2011). Finally, there are disciplines which emerge by bringing together scholars from a range of
disciplines (Singh, 2010; Strick, 2004), reinforcing de Mey’s (de Mey, 1982, p. 140) notion that
interdisciplinarity precedes rather than follows disciplinarity.
Disciplinarity itself became the subject of academic study primarily within the context of interdisciplinarity beginning in the late 1960s. Interdisciplinarity has remained a popular topic, especially in quantitative analyses of scholarship such as scientometrics, which has led to a new surge in disciplinary definitions. A fundamental feature of quantitative analyses is explicit operationalizations of concepts, which in many cases include measurements of interdisciplinarity. Encoded within these measurements are implicit definitions of disciplines. These studies rarely define disciplines explicitly, and when they do, those definitions are often at odds with their operationalizations.

A unique feature of operationalizations of disciplinarity is that, although two studies may organize research into the same type of bins (journals, institutional affiliations, etc.), they may reach vastly different disciplinary conclusions depending on their ontological approach to disciplinarity. Some studies rely on a set of platonic disciplines, categories already defined through some pre-existing taxonomy like Thomson Reuters’s Subject Categories. Others suggest that disciplines define themselves from the bottom up: salient groups of people or papers are discovered, and then labeled with some disciplinary title post hoc. It is also not unprecedented for research on disciplinarity to conflate these approaches. In general, operationalizations of disciplinarity tend to implicitly place the heart of a discipline into one of three categories: publications, people, or ideas. These categories are then used to define each other, such that if we know the discipline of a publication, we can discern the discipline of its authors; if we know the discipline of an idea, we can categorize a publication which uses that idea within that discipline.

Publications: journals, subject categories, and citations. Scientometrics has been presented as “a strong approach to domain analysis because it is empirical and based on detailed analysis of connections between individual documents” (Hjørland, 2002, p. 436). Journal titles are often the most convenient evidence to use when researchers operationalize disciplinarity and have been frequently employed by scientometricians. They are easier to disambiguate than author names and allow for citation tracking through established scientometric databases. From here, a number of studies assign each journal to a discipline using Thompson Reuters’ Subject Categories (SCs). There are over 150 SCs, and every journal in Thompson Reuters’ database is placed into one or a few SCs based on a number of language- and citation-based heuristics (Pudovkin and Garfield, 2002). One study by van Leeuwen and Tijssen (2000) measures the interdisciplinarity of disciplines by seeing how often journals within a particular discipline (categorized according to SC) will cite journals from external SCs. Those disciplines which tend to cite across SCs are considered highly interdisciplinary. Other studies consider journals to be disciplinary, but do not rely on a priori categories. Van den Besselaar and Leydesdorff (1996), for example, use Artificial Intelligence as an exemplary journal of its parent discipline, and follows its citation patterns in order to determine what other journals fall within the scope of AI as a discipline. Many recent studies use a combination of both (Rafols and Meyer, 2010), though they rarely address the implications of such combined methods on assumptions of disciplinarity.

Throughout the studies which utilize SCs (Bordons et al., 2005; Chubin et al., 1984; Morillo et al., 2001; Rafols and Meyer, 2010; Rinia et al., 2002, 2001; Tomov and Mutafov, 1996), it is worth noting the underlying dichotomy: sometimes journals themselves are disciplinary categories used to show interdisciplinarity among subject categories, and sometimes subject categories are disciplinary categories used to show interdisciplinarity between journals. That is not to say these studies are uncritical; many are aware of the limitations of these types of analyses, but continue because it is the
best option available. Rinia et al. (2001, p. 296), for example, acknowledge “that a journals-based field classification of articles is not a perfect means of attributing publications to a discipline. However, it is one of the few classification systems available, spanning all disciplines.”

**People: authors, mentors, and affiliations.** While in the above cases, the place where research appears determines its disciplinarity, other studies determine disciplinarity by who performs the research. As with journals, authors can both be the disciplinary rock by which interdisciplinarity is determined, or they can be objects that gain or change disciplinarity over the course of their academic careers. Sometimes these dichotomies appear in the same study, without the results of one necessarily informing the other (Ni et al., 2013). While the vast majority of journal-based disciplinarity studies rely on Thompson Reuters’ Subject Categories, author-based studies draw from a number of pre-defined taxonomies.

Hargens (1986), for example, uses a set of categories from the Survey of Doctoral Recipients to determine how scholars’ disciplinary affiliation change over the years. In his analysis of nanoscience journals, Schummer (2004) assigned authors disciplines based on their departmental affiliations. As opposed to disciplinary categorizations based on journals, Schummer’s operationalization allows for papers with authors from multiple disciplines to be considered interdisciplinary. He uses this method to argue that although many disciplines contribute to nanoscience research, these disciplines rarely collaborate with one another, and are in fact isolated. His arguments revolve around the idea that individuals are unidisciplinary, articles are interdisciplinary, and journals are simply constructs that may or may not overlap with a discipline. Also focusing on doctoral graduates, Sugimoto et al. (2011) investigated interdisciplinarity changes in a discipline, by studying the degrees of those who both entered the discipline and served as dissertation advisors within the discipline. Cyclicality is introduced here, where disciplinary identity is ascribed by receipt of a doctoral degree in an area, interdisciplinarity is measured by people moving from their discipline of origin to a new discipline, yet the subsequently advised students are still defined according to the degree of record (regardless of the interdisciplinary composition of their committees).

Yet another study, by Carayol and Thi (2005), connects authors to disciplines based on the labs in which they do their research, and the departmental affiliation of those labs, based on a French classification system. In the very same article, the authors measure the interdisciplinarity of researchers based on the disciplines in which they publish. That is, authors are used both as a means of determining interdisciplinarity of a lab, and as beings who are themselves highly interdisciplinary; neither section of the study informs the other. Within the same research project, this may appear startling, but in truth it is only indicative of the trend in scientometrics to use the operational definition of discipline that is convenient for the task at hand. In fact, many of the same articles and researchers change the methods they use to study disciplinarity to support the data available. Groups of co-authors use different methods article to article, occasionally leading to logical inconsistencies in the understanding of disciplinarity which are never addressed. For example, Morillo et al. (2001) suggests disciplines themselves can be interdisciplinary; Morillo et al. (2003) suggests scholars are interdisciplinary by authoring in journals outside of their disciplines; and Borons et al. (2005), including Morillo as a co-author, suggest an author’s discipline is not determined by the journals they publish in because journals can, in fact, be multidisciplinary. In short, the definition of discipline deforms to fit the method.

**Ideas: language, topics, and methodology.** Studies operationally defining disciplinarity by cognitive aspects of a research project are perhaps the least common, given the amount of manual, expert labor
they often entail. Only in recent years have people begun using advanced text mining algorithms to approximate what was often done with hand-coded datasets over the last few decades. In this context, the researchers involved will come up with their own classification scheme which they apply to a group of works that are read and manually coded. In one study, Von Eckardt (2001) manually determines disciplinary contributions of 227 cognitive science papers, showing how their diversity is indicative of a multidisciplinary cognitive science. Furthermore, Von Eckardt refers to previous cognitive science studies which tried to rate multidisciplinarity using the existence of multiple research methods in a single article. In both cases, top-down categories were used to define disciplinarity and begins with papers as the unit of analysis. Similarly, Milojević et al. (2011) purport to examine the cognitive structure of a discipline Library and Information Science using title words; yet, the original sampling frame was constructed using journals—implicitly defining the discipline as a set of particular journals.

More recent studies tend to use mixed-methods approaches, for example combining words and citations, as a means to reaching the cognitive differences between disciplines, fields, and so forth. Van den Besselaar and Heimeriks (2001) perform one such study. They describe a hierarchy of research clusters, beginning at discipline, and subdividing into research fields, which divide into subfields, and those into research topics. These clusters, they argue, can be differentiated using a combination of words and citations – not relying on pre-defined categories, but instead letting communities define themselves, and only then applying disciplinary labels.

**DISCUSSION AND FUTURE RESEARCH**

**Convergence.** Our synthesis reinforces the claim of Shumway and Messer-Davidow (1991, p. 222) who observed: “The disparate character of these studies suggests that no paradigm currently reigns in the study of disciplines- and that the incipient discipline of disciplinarity remains as yet undisciplined”. Our review suggests that complications around disciplinarity may stem from a fundamental tension between conceptualizations and operationalizations of disciplinary. There are, however, some common axes around which conceptualizations, disciplinary narratives, and measurements revolve.

Communication is recognized by all three as a crucial component of disciplinarity, thus reinforcing the use of formal scholarly communication in measurements of disciplinarity. However, the well-known caveat of bibliometric research applies: not all disciplines nor forms of scholarly communication are equally represented in extant data sources (Cronin and Sugimoto, 2015).

The scholars and the way in which they socially organize are also seen as essential to the concept of a discipline across all three approaches to disciplinarity. However, data on individuals—the measurement of the social component—is far less reliable than measurements of journals—a frequent operationalization of communication. Problems of author-name disambiguation in established databases plague the analysis of individual-level bibliometrics (Wouters, 2013). Furthermore, few databases exist to provide non-journal related information on a scholar such as gender, race, age and other demographic variables which may provide more insight into disciplines and how they function not only intellectually, but also sociologically.

The aboutness of a discipline is something dealt with in varied ways by all three approaches to disciplinarity: conceptualizations seem to focus on how a discipline distinguishes itself from previous forms of knowledge-making and -enacting; narratives describe the evolution to and from and the relationships between disciplines; and measurements often employ analysis of single words or bigrams to describe the cognitive nature of a science. Regardless of the way in which it manifests, this remains a
core component of disciplinarity. Jacobs (2014, p. 14) described this tendency towards topical coherence as powerful disciplinary pressures that “act as a centripetal force that pulls scholars towards issued defined as central”.

Institutions remain a dominant force, often due to the credentialing of doctoral graduates. As Abbott (1999) claimed, “disciplines constitute the macrostructure of the labor market for faculty” (p. 126). However, the reliability of institutionally-labeled disciplines for communicating the knowledge-base of a doctoral student may be eroding, given the pervasive and consistent reorganizations and mergers occurring within the higher education system, such that a student who begins a program in one school may graduate from one with quite different signaling. Furthermore, contemporary students may be unable or unwilling to associate under a single disciplinary label (Bowman et al., 2014).

Where data meets disciplinarity. Novel data sources are also challenging pre-existing notions of disciplinarity. One could argue that we are moving away from a space in which disciplines were something “bestowed” upon a young researcher after they had proved their worth in terms of participation in communication, social gatherings, and necessary institutional training. Rather, scholars are living their scholarly lives increasingly online, self-defining their expertise, and are engaging with interdisciplinary scholars in new and technologically-mediated ways. For example, when a scholar creates a Google Scholar, Research Gate, or Twitter account, they can provide free tags with which to self-identify their expertise. Such freedom in labeling represents a new challenge for researchers exploring issues of disciplinary and interdisciplinary identity. Furthermore, students have unfettered access into online communication channels (e.g., listservs, blogs, etc.), allowing them to participate in a wider range of conversations than was previously available to them.

As scholars enact their disciplinarity in increasingly varied ways, so too has the corpora of available datasources for those who study the traces of modern scholarly activity expanded and diversified. Researchers can use sources such a university websites, publication indices (from individual journals to the Web of Science), mailing lists, academic associations (societies, department rosters, etc.), social network profiles, syllabi, reports, theses and dissertations, publications, patents, social media activity and can study these with a range of methods (e.g., content, linguistic, citation, mentorship, collaboration, weblink, and association analyses). However, concomitant with these sources, methods and underlying sampling approaches are implicit conceptualizations of disciplinarity. If they are construed as good enough to produce knowledge about disciplinarity or interdisciplinarity, it follows that their formulation involves some approximation of disciplinarity. Because conceptual repercussions of these bridges are often left implicit, they foster a culture of ambiguity and uncertainty which results in foundational incongruencies within the scholarship. This causes difficulties both within the study of disciplinary measurements, and at its joints connecting to conceptualizations and disciplinary history.

Interdisciplinarity. One possible argument is that disciplines are no longer relevant, given promises of ubiquitous knowledge transfer among disciplines. Whitley has questioned whether “the disciplinary structure of the sciences was ever quite as rigid and strongly bounded as some have claimed” (Whitley, 2000, p. xvi). The ambiguous delineation between disciplines was echoed by Langfeldt (2006): “All disciplines will to some extent be heterogeneous entities with unclear borders.” Yet, even given this ambiguity, Whitley states that changes in the socio-political climate of universities heralds “the decline of disciplinary elites and of discipline-based science” (Whitley, 2000, p. xvii) into sets of “fragmented adhocracies” (Whitley, 2000, p. xvi). This is reinforced by Bordons et al. (2005, p. 453) who argue that “disciplines are losing their identity”. One explanation for this is the heavy promotion of
interdisciplinarity by funding agencies and academic institutions (Porter et al., 2007) and rise in interdisciplinarity across all disciplines over the last century (Larivière and Gingras, 2014). However, as Krishnan so eloquently expressed:

\[ T \]he main problem with the notion of ‘interdisciplinarity’ seems to be that many people who use it do not make explicit what exactly they understand under a discipline or when exactly a disciplinary boundary is crossed with what kind of consequence. This means any useful definition of interdisciplinarity would thus require a workable definition of academic disciplines first, which is certainly not easy.

Perhaps because the definition problem is so pervasive and difficult, some of those measuring interdisciplinarity have seen fit to do away with the binary distinction entirely. Rafols and Meyers (2010) suggest that “interdisciplinarity is an inadequate term or a misnomer,” and Leydesdorff and Rafols (2010) simply claim that interdisciplinarity can mean different things in different situations.

The future of disciplines. Beyond conflicting approaches to disciplinarity and interdisciplinarity, it is important to be mindful that the definitions themselves, whether implicit or explicit, may be highly discipline-dependent. If a discipline is arguing for its own legitimacy given a certain set of criteria, other disciplines might choose not to accept that criterion based on their own criteria for legitimacy. These defining characteristics may be at odds with one another across disciplines, but they do not easily align themselves to any hierarchy of validity. The “correct” angle from which to approach disciplinarity is contingent on the task and set of disciplines at hand. In a sense, this is an exemplar of interdisciplinary research when it works well: a single concept—or boundary object (Star and Griesemer, 1989)—may be employed by scholars with many backgrounds if it is nimble enough to allow multiple interpretations.

Our overview presents a framework of criteria used to define disciplines. This work can help facilitate communication between those who are defining disciplines and those who measure it. However, and perhaps more importantly, our work has identified a great divergence between these two areas and suggest caution for those using metrics to make decisions regarding future of disciplines. This is no triviality. If resource allocation favors a discipline (or interdisciplinarity), this inevitably serves to disadvantage other areas of knowledge production. Federal funding, like it or not, is a zero-sum game. If allocation and measurement is not done with a careful eye, we might lose certain areas of research. This is particularly true in institutions of higher education where mergers, reorganizations, and eliminations are made on the basis of administrative efficiency rather than on the merits of intellectual distinction or value. As Whitley noted, we have seen a shift in “science as a largely autonomous, self-governing enterprise” to a mechanism to achieve “a wide range of political objectives” (Whitley, 2000, p. xi).

As our synthesis has made transparent, decisions based on measurements rather than conceptualizations will arrive at conflicting results on the very nature of a discipline. This inevitably leads to distortions in interpreting the value of that discipline to the institution. Therefore, the future of disciplines is dependent upon the continued assessment of conceptualizations of disciplinarity and development of a theory of disciplines that takes into account the varied perspectives represented in the kaleidoscope of disciplinarity.

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