Introduction

This Element offers a short philosophical inquiry into the relationship between logic and the sciences. This topic is arguably as old as the discipline of logic itself, which we can date back to Aristotle's syllogistic, the general discipline that studies valid deductive arguments.[1] Although the first known occurrence of the term *logikê* (in the somehow contemporary sense of a discipline on its own) comes from the Stoics,[2] it is standardly assumed, as Gisela Striker points out, that "Aristotle's Prior Analytics marks the beginning of formal logic" (Striker 2009: xi). Throughout the *Analytics*, syllogistics provides a uniform theory of deduction for both assertoric and modal contexts within dialectical and scientific realms. For Aristotle the chief distinction between these realms lies in how premises (definitions) are established. In dialectics, definitions typically govern the use or meaning of terms, while in science, they concern the nature of the definienda (objects, not terms). This also explains why only the conclusions of scientific syllogisms express necessary facts. Therefore, Aristotle's *Analytics* presents an early instance of integrating the general discipline of deductive argument with the practice of scientific demonstration.

In contemporary philosophical discussions about logic, on which this Element will focus, the relationship between logic and the sciences has become a focal point, primarily due to the influence of Quine's works in the philosophy of logic. In fact, Quine, who conceived of logic in continuity with the sciences both from a methodological and an epistemological point of view, is typically considered the forefather of what is nowadays known as anti-exceptionalism about logic (AEL for short). AEL is a prominent position and a prolific movement in contemporary philosophy of logic, grounded in the idea that there is significant continuity between various aspects of the sciences and logic.

Despite its popularity and the fact that a considerable amount of research in the philosophy of logic gravitates around anti-exceptionalist themes, some core issues still lack clarity. Most works in the debate remain vague on what should count as logic and what should count as science. Specifically, the terms of the comparison are rarely specified and discussed in a systematic way. This short Element purports to advance the debate on these crucial issues with the hope of fostering our understanding of the fundamentals of logical anti-exceptionalism. In doing so, our goal is not to advocate for or defend logical

[1] Aristotle's logic is known as term-logic since it is about the logical relations between terms, and can be considered as the predecessor of modern predicate-logic. The Stoics, in particular Chrysippus, are credited for the invention of what is nowadays known as propositional logic – see Striker (2009: xiii) and Bobzien (2020) for an introduction to ancient logic. Moreover, Aristotle did not conceive of syllogistic as a science (epistêmê) in its own right.

[2] On this see Diogenes Laertius' *Lives of the Philosophers*, VII 39–41.

anti-exceptionalism – a position on which we intend to remain neutral for the purposes of this Element.

We will proceed as follows. In the first section we provide some preliminary discussion of logical anti-exceptionalism in relation to the question whether and to what extent logic is a science. Specifically, we introduce and compare two ways of understanding logical anti-exceptionalism: (i) in terms of continuity with the sciences, and (ii) in terms of tradition rejection. Then, for dialectical purposes, we lay out a position we label *full-blooded exceptionalism about logic*. We take full-blooded exceptionalism to be a fictional view which nevertheless offers a neat paradigm of a position that exemplifies the various features that recent anti-exceptionalist views have rejected. As it will become clear toward the end of Section 1, the boundary between exceptionalist and anti-exceptionalist positions is not a sharp one, and one could subscribe to an anti-exceptionalist view, for instance, to a greater or lesser degree, depending on which anti-exceptionalist features she endorses.[3] The second section discusses some of the main tenets of Quine's philosophy of logic as a precursor of logical anti-exceptionalism, focusing in particular on his influential criticisms to some traditional categories (such as those of analyticity, necessity, aprioricity) that have been historically attributed to logic. Sections 3 and 4 deal, respectively, with the issue of demarcation in science and in logic. Although no definite conclusion is reached in terms of how to demarcate science from non-science and logic from non-logic, putting these two debates side by side helps to identify some key elements that are essential for effectively guiding the comparison between logic and science. Relying on these elements, Section 5 provides the groundwork for a more systematic comparison between logic and the sciences and contextually discusses three (for limit of space) prominent proposals within the logical anti-exceptionalism landscape by, respectively, Timothy Williamson, Penelope Maddy, and a joint proposal by Ole Hjortland and Ben Martin. The Element closes with a short conclusion highlighting some of the most prominent and pressing issues for logical anti-exceptionalism.

1 On Full-Blooded Exceptionalism

1.1 The Status of Logic

Sciences such as biology, chemistry, and physics (i.e. what goes ordinarily under the label *natural sciences*),[4] primarily aim to provide us with new insights

[3] See, for instance, Sher (2023a). Perhaps Read (2019) also falls under this category.

[4] The emphasis on *natural* sciences is due to the fact that generally within the anti-exceptionalist debate coming from Quine the comparison is between logic (and logical theory) and these sciences (scientific theories about the natural world). There are other ways of understanding the

and explanations about previously unknown phenomena or to offer more comprehensive explanations of already known phenomena. It is, indeed, standard to maintain that through discoveries in these scientific fields, we uncover what are often considered new substantive truths about the world. In other words, the sciences provide us with new and substantive information about certain natural phenomena. What about logic? Is logic akin to the sciences?

Facing this question, one may think that there's some pressure to lean toward a simple affirmative answer to the question: "Is logic a science?" that comes naturally from putting together two prima facie intuitive thoughts: (i) that logic and mathematics are closely linked –in particular, that logic is part of mathematics, and (ii) that mathematics is naturally associated with the sciences. A straightforward way of making the link between logic and mathematics explicit is to consider deductivism in mathematics. As discussed by Maddy (2022: 9), deductivism holds that a mathematical sentence "p" should be understood as asserting the proposition that *p* can be inferred from a suitable set of axioms through a deductive process. For example, the sentence "2 + 2 = 4" is interpreted by proponents of deductivism as stating the proposition that 2 + 2 = 4 logically follows from the axioms of arithmetic. In this view, logic is an integral part of mathematics, suggesting that if mathematics is a science, then logic should be considered a science as well.

As always in philosophy, things may, of course, not be that simple. Although deductivism offers one specific example, it nevertheless illustrates that there are substantive assumptions that have been made in order to establish the link between logic and the sciences. However, one may have reasons not to accept a particular view of the connection between logic and mathematics – that is, deductivism in our example. Alternatively, one may indeed argue that the association between mathematics and the (natural) sciences is not that straightforward. In fact, whether, and to what extent, mathematics is continuous with the natural sciences is certainly an open and interesting question. In this respect, when it comes to the relationship between logic and the sciences a critical question remains: How significantly does logic resemble sciences like biology, physics, and chemistry?

In contrast with the intuitive link between logic and the sciences via mathematics, in several conceptions logic is seen as markedly different from the

term "science" – one may for instance think that logic, perhaps together with mathematics, is a science in some kind of sui generis sense of "science." This wouldn't be a particularly exciting thesis. Be that as it may, we stick with the way in which "science" is understood within the relevant debates in the philosophy of logic. Accordingly, unless specified otherwise, by "sciences" we mean natural sciences. Sections 3 and 4 will be dedicated to a thorough discussion of how to conceive of "science" and how to conceive of "logic."

sciences. First, logic is often taken to provide formal tools that serve as a neutral and impartial arbiter in evaluating scientific and philosophical disputes. Second, logic is often viewed as insensitive to empirical evidence, in terms of both justification and revision. Third, logic is primarily considered a normative discipline, and not a descriptive one which is supposed to be in the business of offering explanations about the world. For instance, logical expressivists claim that since logic has an expressive role – for example, in Brandom's version "to make explicit the inferential relations that articulate the semantic contents of the concepts expressed by the use of ordinary, nonlogical vocabulary" (Brandom 2018: 70) – logical sentences are not representational: they are not meant to make statements about the world and cannot fulfill the function of explaining facts beyond its own realm. In short, conceptions of logic such as logical expressivism see a clear divide between logic and the sciences.

In the philosophy of logic, such a standard divide has been widely discussed. The discussion follows three partially overlapping trends: (i) an epistemological one, where philosophers have focused on whether logic can be justified and/or revised based on empirical evidence; (ii) a methodological one, which particularly addresses whether logical theories should be selected using broadly abductive methods, similar to those employed in selecting scientific theories; (iii) a metaphysical one concerning whether logic's subject matter is about some, perhaps very general and structural, aspects of reality. The complexity of determining whether and to what extent logic is a science requires establishing criteria to demarcate what counts as logic and what counts as science. This important issue will be addressed in Sections 3 and 4.

Before we delve into the discussion about logic's status as a science, it's important to clarify some terminology. In this debate, "logic" is generally used in a restrictive sense, referring specifically to deductive logic rather than to various non-deductive logics like inductive or abductive logic. Throughout this Element, we will adhere to this narrower definition of "logic," focusing primarily on the relationship between deductive logic and the sciences. Furthermore, we will adopt what has been the traditional twentieth-century view of logic as a discipline concerned with reasoning – what Priest refers to as the canonical application of logic (see Priest 2006).[5] Roughly, by logic in the sense of a discipline we mean the interpreted logical theory (or the set of interpreted

[5] This may be seen as a limiting assumption, especially for those who are sympathetic to an instrumentalist conception of logic according to which there's a multiplicity of aims and application of our logic(s), none of which is privileged – see, for instance, Commandeur (forthcoming). That being said, we believe that there are quite convincing arguments for thinking that there's some special connection between logic and reasoning – a connection that may suggest something even stronger than reasoning being the canonical application of logic (on this, see Hanna 2009; Boghossian & Wright 2023; Kripke 2023).

logical theories) – that is, in which each logical constant has an intended interpretation – which is (are) accepted and employed by logicians.

1.2 Quine's Philosophy of Logic and the Rise of Logical Anti-Exceptionalism

The question of whether logic should be considered a science has been a recurring theme throughout many historical discussions on the nature of logic, as evidenced in the works of philosophers like Leibniz, Hobbes, Descartes, Kant, Boole, Frege, Husserl, and Russell, among others. However, this question gained sharper focus and more refined treatment following the influential contributions of Bertrand Russell and Willard Van Orman Quine to epistemology and to the philosophy of logic. In some of their writings (e.g., Russell 1918; Quine 1951, 1986a), they contend that logic bears substantial resemblance to the sciences, particularly the natural sciences, based on epistemological, metaphysical, and methodological considerations. As Bertrand Russell famously claimed, "logic is concerned with the real world just as truly as zoology, though with its more abstract and general features" (Russell 1919: 169).

Quine famously took logic to be continuous with the natural sciences. And many prominent philosophers of logic and philosophical logicians currently sympathize with the Quinean thesis that logic, as a discipline, should be considered methodologically and epistemologically akin to the natural sciences.[6] In the fairly recent debate within the philosophy of logic, this thesis is known as anti-exceptionalism about logic. While the label in connection to logic is due to Ole Hjortland (Hjortland 2017), the inspiration for AEL is from the kind of philosophical methodology developed by Timothy Williamson in his book *The Philosophy of Philosophy* (Williamson 2007). Our discussion of AEL will necessarily encompass multiple facets. Indeed AEL challenges the notion that logic's methodology, epistemology, and subject matter possess an exceptional status and advocates for a more intimate amalgamation of logic with the natural sciences. Additionally, AEL posits a parallel connection between the laws of logic and those governing the world, akin to the relationship seen in scientific laws. Lastly, AEL, drawing inspiration from Quine's concept of evidential holism, implies that the justification of logic mirrors the approach used for substantiating scientific theories.

Two broad ways of characterizing AEL have been proposed and discussed in recent works. The first suggests understanding AEL in terms of *continuity* with

[6] Prominent anti-exceptionalists are, for instance, Pen Maddy, Gila Sher, Gillian Russell, Tim Williamson, Graham Priest, and Ole Hjortland.

the natural sciences (AEL-as-continuity), while the second casts AEL out in terms of *rejection* of some or all of the characteristics that traditionally have been attributed to logic (AEL-as-tradition-rejection). Let's briefly describe these two ways of understanding AEL.

As the very label suggests, AEL-as-continuity is the thesis that there is a significant continuity between logic and the sciences on a variety of aspects (crucially, as said, on methodological, epistemological, and metaphysical aspects). In his 2017 paper, Ole Hjortland introduced the position precisely in terms of such a *continuity*. In an often-cited passage which is typically used as a sort of AEL-manifesto, Hjortland claims that "Logic isn't special. *Its theories are continuous with science; its method continuous with scientific method*. Logic isn't a priori, nor are its truths analytic truths. Logical theories are revisable, and if they are revised, they are revised on the same grounds as scientific theories" (Hjortland 2017: 631, our italics).

Susane Haack, anticipating by several years the recent anti-exceptionalist trend, claims that "[L]ogic is a theory, a theory on a par, except for its extreme generality, with other, 'scientific' theories; and according to which choice of logic, as of other theories, is to be made on the basis of an assessment of the economy, coherence and simplicity of the overall belief set" (Haack 1974: 26).

The second way of characterizing AEL is in terms of a *rejection* of what may be taken to be the traditional conception of logic which sees logic as having a set of very special features which make logic an exceptional discipline.[7] What are these features? According to the way in which Hjortland and Martin introduce the position in some of their joint works, logic possesses some or most of the following features: it is an *absolutely general*, *purely formal*, and *normative* discipline which deals with *truths* that are both *analytic and necessary*, the justification of which is *non-inferential*, a priori, and *empirically non-revisable*. We may call a conception of logic which endorses all these special characteristics a full-blooded exceptionalist conception. In short, *full-blooded exceptionalism*.[8]

We will provide a detailed characterization of full-blooded exceptionalism in Section 1.3. Before proceeding, though, we would like to clarify what we take to be the conceptual relationship between these two ways of characterizing AEL. Arguably, a conception of logic which sees logic in strict continuity with the natural sciences is ipso facto a conception of logic which rejects most (if not all)

[7] This view is championed by Ben Martin and Ole Hjortland in Martin and Hjortland (2022).
[8] This label is inspired from the way in which Da Costa and Arenhart call their anti-exceptionalist conception of logic – *full-blooded anti-exceptionalism about logic* (see Da Costa & Arenhart 2018).

of the features that full-blooded exceptionalism – the purest exemplar of a traditional conception of logic – attributes to logic. In this respect, characterizing AEL in terms of continuity with the sciences entails a characterization of logic that rejects most (or all) of the features that the tradition attaches to logic (in other words, AEL-as-continuity entails AEL-as-tradition-rejection). In this respect, accepting a traditional conception – that is, accepting something in the vicinity of what we call "full-blooded exceptionalism" – means ipso facto to reject the idea that there is a significant continuity between logic and the sciences. Things are not so straightforward in relation to the converse entailment relation. Arguably there are ways of being anti-traditionalist about logic which do not necessarily see logic in strict continuity with the sciences. If that's correct, the characterization of AEL in terms of tradition-rejection does not by itself commit us to establish a continuity between logic and the sciences. In this respect, having both characterizations of AEL on board allows us to see that a commitment to an anti-exceptionalist thesis about logic comes somehow in degrees. For instance, an endorsement of a strict continuity between logic and the sciences matches what may be called a radical form of anti-exceptionalism (borrowing the label from Da Costa & Arenhart (2018) we may call it "full-blooded anti-exceptionalism"). However, there may be progressively milder forms of AEL based on a rejection of some of the traditional features of logic. Be that as it may, regardless of whether we take AEL as continuity or as tradition rejection, insofar as the former entails the latter and thus an acceptance of the traditional view of logic as exemplified by full-blooded exceptionalism entails a full rejection of the continuity thesis, it is helpful to dig deeper on what exactly are these characteristics traditionally associated with logic which AEL rejects. We do that by providing a characterization of full-blooded exceptionalism, to which we now turn.

1.3 On *Full-Blooded Exceptionalism*

Full-blooded exceptionalism is a view that takes logic to be fully general, formal, normative, analytic, necessary, a priori, and non-revisable.[9] We do not claim that full-blooded exceptionalism as such is a view that has been actually endorsed in the history of logic. We do, however, take it as a placeholder for a position that collects all the features that have been historically attributed to logic by a variety of philosophers and logicians.

[9] On the absolute (rational) unrevisability of logic see Hofweber (2021). See also Leech (2015) and Field (1996).

In this respect, its role in this Element is that of providing a neat paradigm of a view that exemplifies the various features that recent anti-exceptioanlist views have rejected (if not all, at least most of them). Let us analyze the features of full-blooded exceptionalism in some detail.

We begin with ***Generality***, a feature that has been almost universally associated with logic.[10] An easy way to understand the *generality* of logic is to argue that, unlike the laws of biology, chemistry and physics, logical laws are typically conceived as wholly general, applying to all entities with no restrictions. In this regard, logical laws are considered to have the broadest scope of all laws, applying universally to everything without exception. On a minimalist interpretation, the generality of logical laws could be seen as exceptional only in a quantitative sense – having a higher, perhaps the highest, degree of generality – rather than in a qualitative sense – that is, as marking a substantive difference in nature between logic and the natural sciences. This conception of generality is best understood when combined with the, perhaps controversial, idea that quantification in logical truths (such as "for every x, either x is F or x is not F") is taken to be absolutely unrestricted. – that is, as requiring the existence of an all-inclusive domain of quantification.[11]

Historically, however, the notion of generality has been tied to various ideas traditionally associated with logic, giving it a less minimalist interpretation and aligning it more with a substantive sense of exceptionalism concerning the nature of logic. These ideas include, among others, the Kantian perspective that logical laws are universal and necessary and constitutive of rationality; Frege's thought that his logical system (the *Begriffsschrift*) is like the language Leibniz sketched, a *lingua characteristica*; Wittgenstein's notion of logical truths in the *Tractatus*, which posits that logical truths lack proper meaning as they do not limit the realm of possibilities; and finally, Carnap's belief in logical truths as analytic truths.

In the Kantian perspective, logic is a general art of reason (*canonical Epicuri*) dealing exclusively with *general*, namely universal and necessary, laws of thought. Logic is based on a priori principles, from which it is possible to derive all its rules, understood as rules to which all knowledge should conform. Such principles are independent of any content and are therefore determinable a priori.

Frege too viewed logic as a fully general discipline. As van Heijenoort points out (van Heijenoort 1967), Frege's belief in the superiority of his *Begriffsschrift*

[10] Contemporary exceptions to the generality of logic are Da Costa & Arenhart (2018) and Payette & Wyatt (2018).

[11] See the collection of papers edited by Agustin Rayo (Rayo 2009) for a discussion about absolute generality.