

**Anti-exceptionalism about logic and the a priori/a posteriori divide*****Anti-excepcionalismo lógico e a divisão a priori/a posteriori*****Jonas Rafael Becker Arenhart¹**

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ABSTRACT

Anti-exceptionalism about logic is the view that logic is not special; it is just like empirical science in many respects. In particular, it is thought that an anti-exceptionalist must also hold that logical theories are completely *a posteriori*. However, it is not clear what it means to say that logical theories are *a posteriori*, for the *a priori/a posteriori* divide has been explored from different perspectives in contemporary philosophy. The central claim of this paper is to argue that logical anti-exceptionalism is quite compatible with the *a priori*, if the *a priori/a posteriori* divide is understood in the lines recently developed by Tuomas Tahko. The conception advanced by Tahko is characterized by an interplay between *a priori* and *a posteriori* knowledge, generating a bootstrapping relation in which one kind of knowledge constantly substantiates the other. We further present some of the advantages of the bootstrapping approach over the current epistemology associated with anti-exceptionalism.

Keywords: anti-exceptionalism. *a priori*. *a posteriori*. bootstrapping. epistemology of logic.**RESUMO**

O anti-excepcionalismo sobre lógica é a visão de que a lógica não é especial; é como a ciência empírica em muitos aspectos. Em particular, acredita-se que um anti-excepcionalista também deve sustentar que as teorias lógicas são completamente *a posteriori*. No entanto, não está claro o que significa dizer que as teorias lógicas são *a posteriori*, pois a divisão *a priori/a posteriori* tem sido explorada de diferentes perspectivas na filosofia contemporânea. A reivindicação central deste artigo é argumentar que o anti-excepcionalismo lógico é bastante

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compatível com o a priori, se a divisão a priori/a posteriori for entendida nas linhas recentemente desenvolvidas por Tuomas Tahko. A concepção avançada por Tahko é caracterizada por uma interação entre conhecimento a priori e a posteriori, gerando uma relação bootstrapping na qual um tipo de conhecimento constantemente substancia o outro. Apresentamos ainda algumas das vantagens da abordagem bootstrapping sobre a epistemologia atual associada ao anti-excepcionalismo.

Palavras-chave: anti-excepcionalismo lógico. a priori. a posteriori. bootstrapping. epistemologia da lógica.

1 Anti-exceptionalists united against the a priori

Anti-exceptionalism, in a few words, is a view on the nature of logic according to which logic is not special among the sciences. In other words, logic is closer to physics, biology, chemistry, and other empirical sciences in many more respects than the tradition has thought; this proximity includes similarity in issues such as theory choice, the appropriate epistemology, and the nature of evidence allowed for a logical theory. These features, of course, cannot serve as a definition of anti-exceptionalism, but they provide general guidelines for those interested in the view. In particular, it is very common to find among characterizations of anti-exceptionalism the claim that, due to this similarity with empirical science, logic is *not* a priori. According to Hjortland:

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), p.632, emphasis added.

The idea that logic is not a priori seems to make perfect sense at first sight for an anti-exceptionalist, given the alleged proximity between theories in logic and theories in *empirical* science. After all, by being empirical, *empirical* science is a

posteriori, no? But let us not get ahead of ourselves so fast.

So far, in the logic literature, the anti-exceptionalist's claim that logic is not a priori has been constantly mixed with diverse concepts that are not necessarily tied to the distinction between a priori and a posteriori. Frequently, the suggestion of the a posteriori character of logic is entangled with many different concepts, all of which are appealed to when it comes to characterize the nature of logic in an anti-exceptionalist approach. The a posteriori nature of logic is somehow closely related with the very possibility of *logical theory revision*, or with the *kind of evidence* that is available to logical theorizing, and also with the *nature of logical knowledge*. Hjortland, for one, makes the following claims:

When we reject the apriority of logic, we are left with a less glamorous alternative. Basic logical knowledge is as hard-earned as the knowledge of physics, chemistry, or economics. The fortunes of logic are no less tied to a posteriori evidence than other sciences. In Quine's phrase, logic is as revisable as the natural sciences [...] ([Hjortland, 2019](#)), p.250-251.

Here, failure of being a priori is related to issues as diverse as knowledge acquisition, the character of evidence allowed in logic, and, finally, to the very possibility of logical theory revision. In the sequel of Hjortland's paper, revision of theories and the nature of evidence are separated features; speaking about anti-exceptionalism, Hjortland claims that:

At the heart of the position are three familiar Quinean claims: gradualism, that logical theories are continuous with non-logical scientific theories; revisionism, that logical theories are revisable by pretty much by the same standards as other theories; and nonapriorism, that logical theories ultimately answer to a posteriori evidence. ([Hjortland, 2019](#)), p. 251.

We find here, then, that logical non-apriorism is tied to the kind of evidence that logical theories must answer to: evidences that are empirical. ([Martin, 2021](#)), p.

9070. makes a similar move:

While traditional accounts of logical epistemology when it comes to validity have appealed directly to intuitions and definitions, none of these accounts have provided anywhere near a detailed enough explanation of how theory-choice between different logics of validity could occur. Recently, in an attempt to rectify the failures of these accounts, a logical epistemology which has Quine's (1951) *empirical holism* as its progenitor has been proposed, emphasizing similarities between logical and scientific methodology [...]. According to this account of logical epistemology, logical propositions are not directly justified by intuitions or definitions, but rather logical theories are justified by their ability to best accommodate relevant data. In other words, logical theories are justified by abductive means.

Although the a priori is not explicitly appealed to here, the idea is that there is an opposition between a new (or renewed) epistemology and a traditional epistemology for logic (and this is present even in more recent, 'watered down', characterizations of anti-exceptionalism, as in (Martin e Hjortland, 2022)). Traditional epistemology is said to: be a priori, to appeal to notions such as a priori justification, and in order to do that, to rely either on intuitions or else on a semantical notion of analyticity, both of which are considered too problematic, to say the least. Anti-exceptionalism, on the other hand, by avoiding the a priori nature of logic, is said to avoid these troublesome partners (intuition, analyticity), by granting that logical theories have to be warranted by their capacity to account for the a posteriori data. By leaving the notion of the a priori aside, then, one has a better picture of the theory choice process in logic, which is related by the anti-exceptionalists to the epistemology of logic (for further discussion on these issues, see (Becker Arenhart, 2024)).

Even in the face of all these complaints against uses of the a priori in logic, in this paper we suggest that an anti-exceptionalist needs not entirely reject the notion of a priori, without sacrificing her anti-exceptionalism. There are many reasons favouring

that move. To begin with, as far as that notion is not properly defined by current anti-exceptionalists, one may not know what one is leaving behind when recommended to abandon the a priori. As a second reason, one should take into account that the discussion on the very nature of the a priori has evolved in metaphysics and philosophy of language, and that a closer look in the literature furnishes us with better prospects on how to understand the distinction between the a priori and a posteriori that can be useful for anti-exceptionalism. As a third reason, there is the fact that logic may involve a priori knowledge, and that connection is not detrimental to some kinds of approximation that the anti-exceptionalist wishes to make with empirical science, in particular, with the idea that logic may be a priori and still, revisable (see, for instance, (Warenski, 2009) for one connection of a priori and revision, and see (Biggs e Wilson, 2022) for another discussion on the possibility of logical anti-exceptionalism and apriorism). That compatibility should not come as a surprise, after all, empirical science has a priori elements too. It is a naive view of science one that holds that empirical science is never involved with a priori elements (see (Chakravartty, 2013) for an appropriate discussion on misunderstandings of empirical science and its connection to the a priori, and also (Tahko, T., 2021) for comments on misconceiving ‘science’ with ‘a posteriori’). So, in that sense, bringing the a priori to the anti-exceptionalist party is a welcome addition to make it closer to actual science too.

In order to reconnect a priori and anti-exceptionalism, we shall present a recent approach to the a priori advanced by Tuomas Tahko, as based on the notion of *metaphysical modality* (see (Tahko, T. E., 2008, 2011; Tahko, T., 2021)). Tahko’s conception is based on a view of the a priori/a posteriori divide that does not conceive such concepts as mutually excluding, but rather as *complementary modes* of knowledge acquisition in the process of development of our scientific theories. After presenting Tahko’s view and discussing its basic elements, we shall apply it to the case of logical theories (and some adjustments to Tahko’s views will be required). Then, we advance and discuss how Tahko’s (2008; 2011) *bootstrapping* strategy for the relation

between a priori and a posteriori may be useful in the current discussions of logical anti-exceptionalism to overcome worries with the a priori. The discussion not only grants that logical knowledge may be seen as a priori, independently of conferring a *necessary* status to it (that is, independently of discussions on logic's modal status), but also helps us with many of the distinctions that are dear to the anti-exceptionalist, in particular, clarifying the relation between logical epistemology with logical theory choice and logical revision, issues that are conflated in current literature.

The paper is structured as follows. In section 2 we present, in a few words, the conception of a priori according to Tahko's proposal, as well as the *bootstrapping* relation between a priori and a posteriori knowledge. It is important to emphasize that we use it as a starting point for our purposes here, and that this is not the place for a defence of the view (which one may find in Tahko's papers, of course), or comparisons with other approaches to the a priori in current literature (which would require a different paper, with different goals). In section 3, we apply Tahko's approach to the case of logic, showing how logical knowledge may be a priori in that sense, and how the bootstrapping relation can be used to explain how empirical evidence may be required for logical theory choice and revision, in agreement with the general characterisation of anti-exceptionalism. In section 4, we argue that this view has advantages over current anti-exceptionalist accounts of logical epistemology. We discuss, in particular, how important topics in philosophy of logic that are dear to anti-exceptionalists are not prejudged by the framework offered by Tahko. We conclude in section 5.

2 The a priori, the a posteriori, and the bootstrapping relation

The traditional approaches to a priori and a posteriori require that we sharply distinguish them, typically framing the distinction in terms of complete presence or absence of a role for empirical experience in the given source of knowledge. A priori

knowledge is defined in these terms as knowledge that is obtained *independently* of experience, and a posteriori knowledge is knowledge that depends on experience, or knowledge that has its source in experience. The major problem with those characterizations is that it is very hard to separate anything that is completely independent of experience, and also, most of our experiential knowledge rests at least on some a priori elements. Furthermore, the role of experience in these definitions is problematic: is it merely *enabling* the given knowledge, or does it also play an evidential role? Even the very understanding of what counts as experience in these contexts is not without problems (for further discussions, see ([Tahko, T., 2021](#))).

In order to introduce an appropriate notion of a priori knowledge and its relation to logic, one needs to distinguish appropriately between what the notion of ‘a priori’ is being predicated of: justification, reasoning, or knowledge. Certainly, knowledge requires justification and truth, while justification may appear without truth, and truth also may appear without justification. Our attempt in this section is to present in general lines Tahko’s characterization of a priori reasoning and a priori *knowledge*, and then, in the next section, to apply it to the case of logic, arguing that it suits pretty well some of the anti-exceptionalist tenets presented before (certainly, discarding the claim that logic is not a priori). Again, it is important to remark that this is not the place to advance a *defence* of Tahko’s understanding of the divide, or to compare it with other approaches to the concepts under examination here. We take it as a starting point for our discussion of one possible way to frame the anti-exceptionalists’ relation with the a priori/a posteriori divide. We claim that its fruitfulness in this role speaks in its favour, but still, we acknowledge that this does not exclude that other approaches to the divide are not available or that they are not equally interesting in this context. Our investigation is one step in filling a gap on what concerns the obscure relation between anti-exceptionalism and the a priori/a posteriori divide.

The major claims concerning a new proposal for a priori knowledge by Tahko includes the following features (see ([Tahko, T. E., 2008, 2011](#))):

- 1) a priori and a posteriori are not independent, but are rather on a bootstrapping relation in which one constantly feeds the other;
- 2) a priori propositions may fail in the actual world, but still hold in distinct possible worlds;
- 3) the a priori is related to the space of possibilities. Tahko considers that the a priori is grounded on metaphysical possibility, allowing that we make legitimate connections between the propositions reached a priori and what is actual.

Let us now go through each of these features.

According to Tahko, a priori reasoning is ‘the rational activity that human beings engage in when trying to reach a priori knowledge’ (Tahko, T. E., 2008), p. 58-59. Through a priori reasoning we reach a priori propositions. It seems at first that a priori propositions include propositions that are logically valid and logically consistent, obtained through the rules of logic ((Tahko, T. E., 2008), footnote 1, and pp.64-65; but see our discussion ahead). These characterizations involve important notions such as logical validity, consistency, and rules of logic, which would make the a priori in a certain domain relative to a choice of logical system. We shall comment on this dependency in the next section. For the remainder of this section, we ask the reader to keep these notions in an informal mode.

Intuitively, Tahko’s proposal is that we reach a proposition a priori if the proposition was obtained by a priori means, which *includes* the use of rules of logic and the requirement of consistency. This presupposes that we apply such methods on an already available basis of propositions, which constitute a kind of established *background knowledge*. What is it? The background over which we elaborate and reach for a priori propositions is typically a posteriori; we must have a basis on which to apply the a priori methods. Once the methods are applied, we may verify whether the a priori proposition just advanced is true in the *actual world*. This is the bootstrapping process (and this answers to issue 1) of our previous list).

I will suggest that the (non-analytic) a priori, rather than strictly independent of experience, is always one step beyond experience. To be able to reach this step, we must have an a posteriori framework to take us just below that next step. Furthermore, once the a priori step has been firmly verified, by a posteriori methods, it becomes a part of the established a posteriori framework. What I mean is that the a priori is in a constant bootstrapping relationship with the a posteriori. Despite this intimate connection with the a posteriori, a priori reasoning is a distinct, crucial method of inquiry which is not reducible to the empirical. (Tahko, T. E., 2008), p. 58.

So, experience is required both as providing a *previous* basis from which new a priori propositions are reached, and also as the test for a priori propositions, *after* they are advanced. Tahko puts it as follows:

the truth of an a priori proposition - unless it is necessary [...] - will always be verified by empirical means. Obviously, we might have gotten the empirical story wrong and if this is the case then it would seem that the proposition is not, and never was, true in the actual world. It will still be true in the actual world that the proposition is true in some possible world, just not in this one, but this is another matter. So, it seems that, due to the fallible nature of empirical information itself, there is always a possibility that further empirical information might falsify a priori propositions that were previously believed to be true. (Tahko, T. E., 2008), p. 60.

The bootstrapping process by itself suggests that once an a priori proposition is reached, it must be dependent on the a posteriori background, and also, after advanced, it must be tested against experience. Then, there is clearly no independence between the notions. Furthermore, as the quote also indicates, a priori propositions may fail the test of experience. In this sense, a proposition may be a priori, and still

not apply in the actual world. This leads us to an important feature of the a priori, as developed by Tahko, which is the distinction between *a priori propositions that hold in the actual world* on the one hand, and those that *hold in any non-actual world*, on the other hand. The propositions do not lose their a priori status when they are discovered not to hold in the actual world.

This important distinction is of utmost relevance. The plan is to follow Kripke in dissociating the a priori and a posteriori, which are epistemic notions, from necessity, which is a metaphysical notion. Some propositions may be a priori, and still, not be necessary, while some propositions may be necessary, and still, not be a priori. The distinction helps us with the alleged infallibility of a priori propositions, and shall help us, in what follows, with knowledge of propositions of pure mathematics (although Tahko does not make this particular use of it). Consider the case of Euclidean geometry. Following the distinction between a priori propositions that hold in the actual world, and those that fail in the actual world, the axioms of Euclidean geometry are still a priori knowledge, it just was found out that some does not apply to the actual world when considered as a theory of physical space. As we see it, one could put the issue as follows: as applied mathematics, concerning the global structure of physical space in the actual world, Euclidean geometry fails, but we still have a priori knowledge of its axioms, it is a mathematical theory on its own rights (and this answers to question 2) above, see also ([Tahko, T. E., 2008](#)), p. 60-61.).

The bootstrapping process generates a development of knowledge acquisition having roughly the form of a tree of knowledge. Given a knowledge basis, which consists of a revisable set of propositions – the background knowledge, with propositions enjoying at least partial empirical support and predictive or explanatory success, in general both –, one may have a new set of problems (either because the current theory does not solve all the problems expected, or because new problems appear, or because one has new epistemic goals). One must provide solutions to these problems. These solutions consist of a priori propositions, advanced as *possible* solutions, *possible*

ways of developing new knowledge. In the tree of knowledge analogy, they represent the branches that ramify from the background knowledge. They are then verified or tested by empirical means, and once we have some (always fallible) evidence for their truth, they join the boat, and we are ready to go one step ahead.

The example of the change from Newton's to Einstein's theory of gravity is used by Tahko to illustrate the bootstrapping method. In a nutshell, it goes as follows: since the times of Newton, it was known that gravity bends light. However, Newton's theory of light as consisting of corpuscles (the corpuscular theory of light) was not appropriate to account for the phenomena. This sets the stage for a further development of a more appropriate theory (Newton's theory is the background knowledge), from which Einstein advances. Through further a priori theorizing, considering the possible solutions to the problems faced by Newton's theory, Einstein advanced the claim that if light is understood as electromagnetic waves, the difficulties may be properly met, which is subsequently confirmed by experience. This is an example of the bootstrapping relation between a priori and a posteriori (([Tahko, T. E., 2011](#)), p. 157.; ([Tahko, T., 2021](#)), p. 357.). The example indicates that a priori propositions are not only reached by means of consistency and logical reasoning alone, but by scientifically constrained hypothesizing, by investigating the possibilities elicited by the background knowledge.

The next problem is to put some constraints on the possibility that the a priori leaves open. Given a background knowledge, established by the bootstrapping method, how new possibilities are limited? Isn't it just the case that anything goes? Tahko's example of a problem in the motor of a car illustrates the situation (([Tahko, T. E., 2011](#)), p. 156.). Suppose that your car motor doesn't start in the morning. What could the problem be? There are many *possible* solutions, many distinct paths to be explored, and someone knowing in detail the workings of the car may try many distinct possibilities. The possibilities are limited by the facts about cars and the features that may affect the functioning of the motor. It is the nature of a motor which guides

us in hypothesizing about what went wrong with *the motor*. Something similar needs to enter the stage when it comes to knowledge about reality (in making theories about light, for instance). What limits the possibilities of a priori hypothesizing about reality?

Here enters the modal basis. “The modal basis of any given scenario about how the governing conditions of reality might work must be based on the different possible states of affairs that could explain empirical observations” (([Tahko, T. E., 2008](#)), p. 65.). When we deal with the empirical world, based on what we already know and what is the problem being dealt with, there is an array of possible ways to propose solutions to the problem, based on already available knowledge. The modality is grounded in conditions of reality, the basis is metaphysical modality. That is, in suggesting new proposals, we look for those that are possible when considering the metaphysical possibilities, which are on their turn grounded in the essences of the objects being dealt with (([Tahko, T. E., 2008](#)), p. 66.)³.

We need a priori reasoning to determine what is possible. And why cannot a priori reasoning be just guesswork? Well, because what is possible is determined by the identity and existence conditions of the involved entities. The ‘guess’ has to be based on something, and it can only be based on the natures of the involved entities. Thus, this is not merely to equate a priori propositions with contingent propositions, far from it. ([Tahko, T. E., 2008](#)), p. 66.

This answers to the modal basis problem (our question 3 raised before). The bootstrapping process requires that some a priori propositions be advanced, obtained by a priori reasoning. Recall that a priori propositions were characterized as consisting in part of the propositions that are consistent and logically valid. Here we see that a

³ It is not our purpose in this paper to commit to Tahko’s view on the essence of objects, but only to describe how the bootstrapping relation may be limited according to Tahko’s view. This is related to the notion of possibility we shall discuss soon.

priori propositions are obtained by considerations of metaphysical possibility, which extrapolates mere logical validity. We are allowed to consider the possible states of affairs that would answer the problem. And that exploration is conducted a priori. This means that we have to consider the restrictions imposed by metaphysical possibility over the entities concerned in the background knowledge in order to examine what is further possible for them. In considering the open possibilities we are reasoning a priori, and still, constraining the field of possibilities. This puts the process to work in a next stage, when we examine the truth of the propositions advanced in the actual world.

Let us pack everything we have described. The a priori is closely related to the a posteriori through a bootstrapping relation. Given a background basis of a posteriori and possible a priori knowledge, and given problems to solve, one advances a priori conjectures about how to address the problems (how to modify the theory, how to reach new propositions, and so on). These new propositions are a priori, they are obtained by a priori reasoning, and are tested against experience. If experience authorizes them, then they may join the body of established knowledge. Notice that this does not forbid revisions. A posteriori verification may go against the proposed solution. A priori knowledge is fallible in a sense, not necessary. A proposition or theory may be known a priori, and still, fail to be true. If it does not apply to the actual world, it still describes a distinct world, however. Euclidean geometry is known a priori, but does not correctly describe the physical space of our world (at least not globally). It could be remarked that Tahko's framework makes complete sense of Graham Priest's pluralism concerning pure mathematics: each mathematical theory is right when taken on its own, but some of them may fail to correctly *apply* to specific situations (as defended, among other places, in ([Priest, 2013](#))).

Tahko's a priori is revisable only insofar as the background knowledge of which it is part changes in accordance with new a posteriori evidence. Even if we can formulate new theories via a priori means, that does not exclude the a posteriori

process through which some of the background knowledge shall be tested. The a priori and the a posteriori are not orthogonal modes of knowledge. In fact, the development of our theories about reality is fed by the mutual understanding between both. In Tahko's view, a priori propositions must be consistent (the possibilities examined must be consistent), but consistency is a matter relative to a logical theory, and this is related to the application we shall make of this framework to logic.

3 Anti-exceptionalism and the a priori

Now, let us check how the bootstrapping relation may help us understand knowledge of logic in the context of anti-exceptionalism.

Recall that anti-exceptionalism is sometimes characterized as involving a notion of logic as being purely a posteriori. This only makes precise sense once the notion of a posteriori (and a priori) has been precisely defined and properly understood. Current attempts to frame the view are based on a renewed version of the Quinean web of belief. As Boghossian puts it:

According to this account, warrant accrues to a logical principle in the same way that it accrues to any other empirical belief, by that principle's playing an appropriate role in an overall explanatory and predictive theory that maximizes simplicity and minimizes the occurrence of recalcitrant experience. We start with a particular theory T with its underlying logic L and from T we derive, using L , a claim p . Next, suppose we undergo a string of experiences that are recalcitrant in that they incline us to assent to not- p . We need to consider how T might best be modified in order to accommodate this recalcitrance, where it is understood that one of our options is to so modify the underlying logic of T that the offending claim p is no longer derivable from it. We need to consider, that is, various ordered pairs of theory and logic — $\langle T, L \rangle$, $\langle T', L \rangle$, $\langle T'', L \rangle$, ... , $\langle T, L' \rangle$, $\langle T, L'' \rangle$

... – picking that pair that entails the best set of observation sentences. Whatever logic ends up being so selected is the logic that is maximally justified by experience. ([Boghossian, 2001](#)), p. 233.

According to this picture, then, evidence for a system of logic is obtained by the system's overall success in facing experience. Logic gets its warrant from the role it plays in our web of belief. As we can see from its description, the method of theory choice plays a major role here, and most of the times, the notions of theory choice and epistemic warrant get somehow conflated (on purpose, it seems; recall the quote by Ben Martin in the first section, where it was complained that traditional epistemology of logic cannot give an appropriate picture of theory choice).

We believe that the epistemology of logic and logical theory choice should be treated separately (see also ([Becker Arenhart, 2024](#))). As we shall see, it is a virtue of the bootstrapping relation between a priori and a posteriori that it allows us to do so. Furthermore, by adhering to this Quinean view of the epistemology of logic, the traditional picture obliterates the distinction between pure and applied logic. This conforms to the Quinean strictures that only applied mathematics should be accepted in the Neurathian ship. However, these strictures are very unfair to pure mathematics, and in particular, to pure logic. Anti-exceptionalists, by getting wedded to this picture, end up tying the epistemology of logical theory to application, which leaves pure logic completely neglected. The bootstrapping strategy helps us solving this issue too.

Let us check how to apply the understanding of the a priori/a posteriori divide presented in the previous section to the epistemology of logic. The proposal is that knowledge of logic may be a priori, and still, evidence and experience may be important in the process of choosing the logic that is the case in the actual world. This not only allows one to claim that logic is a priori, but also opens up a place for experience in theory choice, which is what the anti-exceptionalist was suggesting all the time.

The first worry to be dispelled is whether the process applies to logic at all. Indeed, it seems suitable to empirical investigations, but does it apply to logic? Sure. Tahko does not mention this application, but he comes close enough when considering other contexts where a priori reasoning is employed:

The purpose of this model is to illustrate how a priori reasoning functions, and the hypothesis is that a priori reasoning is required for all of these different rational activities: scientific hypothesising, philosophical thought experiments and thinking about counterfactual situations in everyday contexts. (Tahko, T. E., 2011), p. 160.

Logic and mathematical reasoning employ, in fact, much hypothesizing, reasoning in counterfactual situations, and thought experiments. The fact that one of the examples mentioned concerns Euclidean geometry is also indicative. So, there is nothing in principle that could prevent that the characterization applies also to logic.

One point requiring discussion, however, is the use of *metaphysical possibility* to constrain a priori reasoning (see also our footnote 1). It seems that if logical knowledge is to be a priori, and that the exploratory reasoning of the possibilities is to be restricted to metaphysical possibilities, we shall fall short of the whole dimensions of non-classical logics and the richness of mathematical structures that have no clear sign of application to reality (some of which are clearly not applicable). Are there good reasons to use *metaphysical modality* to constrain the field of possibilities? As the major reason actually advanced, Tahko claims that only with metaphysical modality can one maintain a manageable size in the growth of the tree of knowledge (i.e. the branching of a priori suggestions that are allowed on the a posteriori established basis):

The suggested interpretation [of the growth of the tree of knowledge] is that these scenarios concern metaphysical modality. However, the model may be accurate even if this interpretation is not the correct one, and it will not

be possible to defend this interpretation in any detail here. Our purpose is simply to present the model in its general form, and it is only an advantage if it can be combined with different accounts of aprioricity. In any case, it should be noted that the scenarios are not to be interpreted as conceptual possibilities; we also wish to strongly resist reducing a priori reasoning to conceivability or conceptual analysis. Why is this? Well, if the branches of the tree were simply conceptual possibilities, then the tree would quickly grow beyond what is manageable: everything from philosophical zombies to Disney fairy tales is conceivable; indeed, conceivability appears to be entirely unrestricted. But the tree of knowledge cannot be unrestricted, we have to be able to rule out metaphysically impossible scenarios that might nevertheless be conceivable, as otherwise we would never be able to make progress due to the infinite number of (conceptually) possible scenarios. (Tahko, T. E., 2011), p. 161.

The reason, then, is to restrict the possibilities to a manageable size. However, it is not clear why even the number of metaphysical possibilities is not infinite, so that metaphysical possibility is not up to this task. Furthermore, fairy tales and wild scenarios are important in exploratory investigations and thought experiments. So, if the model is to do justice to scientific practice, the kind of modality involved must be broader. We suggest that logical possibility is the appropriate case⁴. Indeed, the only restrictions to a priori reasoning is that it must be coherent and consistent. However, these notions are *logically relative*, in the sense that they are relative to a system of logic. In this sense, what we suggest is the following: given a background knowledge scenario, one is free to explore any possibility that is logically coherent, which means

⁴ And whether this notion of logical possibility is to be grounded on a special conception of conceivability or some special interpretation of the logical constants, we shall not deal with these issues here. Our sole goal is to argue for the use of logical possibility as an adequate ground for aprioricity in the sense just defended by Tahko.

that the coherence of a scenario is to be evaluated by the logical standards internal to the scenario. This allows that even scenarios that encapsulate contradictions are allowed to be explored, provided that the accompanying logic is able to deal with them (discussing the specifics of these worlds, or even the possibility of impossible and trivial worlds would take us very far afield; however, they seem to be possibilities that can only be investigated a priori, and cannot be left outside of the account; see (Weber e Omori, 2019), for instance).

The consideration that in examining the open possibilities to deal with a problem one must also be able to envisage that a change of logic cannot be ignored. In this sense, the restriction to metaphysical possibility may also be too much of a restriction. Think about quantum mechanics and its incompatible properties (such as position and momentum). One solution to this problem consists in accepting that there are incompatible properties, and this has been historically related with abandoning a form of realism about quantum entities (the entities, it is thought, have some properties which are not always well defined for them). Another possibility is to change logic, adopting a quantum logic. At least for some time, it was thought that this option would permit a kind of realism about the possession of properties in the quantum domain. In this sense, the very possibility of changing the underlying logic is also one of the possible paths open for theory revision. That would require that the possibilities available allow that distinct logics be envisioned. Of course, then, as we mentioned, the requirement of consistency would be internal to the framework adopted.

Consider now the field of argumentation in natural language, possibly reasoning with vague information. Given some (let us say) classical inference that apparently fails in this context, one may envision changing logic in order to deal with scenarios involving vagueness. Other options involve changing our theories to account for such fuzzy entities without changing the logic. Anyway, the changes of logic must be accounted for as being part of the open possibilities.

So, not only does the possibility required in these cases need to take into

account distinct logical scenarios, but also this must be the case if we are to deal with knowledge of logic itself in the proposal. The picture we have is, then, that bootstrapping concerns the application of logic to a given domain, which may be simply human inferential practices, broadly understood, or more restricted cases, such as inferences in mathematics or in vague contexts (or any other kind of restriction): once information is provided by experience, one may change the system in case recalcitrant experience requires it. Also, by requiring that we investigate the possibilities, distinct systems may be known a priori, without it requiring that they are actually chosen as the appropriate one to the case in hand. The distinction between choice of a system and knowledge of logic is preserved. The resulting picture is coherent with Tahko's view that the development of any science is marked by periods of intense a priori investigation followed by periods of a posteriori research.

Perhaps the issue of the scope of logical possibility could be further sharpened if we distinguish, following ([Hjortland, 2019](#)), p.255., two approaches to logical consequence: the *metalinguistic* approach, and the *non-metalinguistic* approach. According to the former, logical consequence is a property of language, and the data to be evaluated when discussing logical consequence concern semantic properties of logical operators. According to the second, logical consequence concerns the most general features of reality, with logical validities being a description of the general structure of the world. In this case, one should look for the possible ways in which the structure of things behave in order to determine the correct logic. In each of the options, logical possibility concerns different subject matters (semantics, or reality), but still, the exploration in each case concerns what is possible from a logical point of view.

Consider the cases of semantic paradoxes, such as the Liar. Some see it as requiring that a change of logic should be effected (see ([Priest, 2006](#))). The derivation of the paradox would be the evidence to be accounted for, and which the background logic (i.e. classical logic) allegedly cannot account for. This concerns a metalinguistic

approach to logical consequence, and the point here is that we should explore the possibilities, on what concerns the meaning of connectives such as negation, so that the alternative new theories can accommodate the derivation of the Liar without exploding into triviality. On the other hand, one could take a non-metalinguistic approach to logical consequence, and claim, for instance, that reality involves incomplete objects, failing the law of excluded middle (perhaps due to quantum mechanical reasons, involving incompatible properties). In order to cope with that, one would need to investigate the possible ways to solve the problem, given the classical logic background knowledge available, perhaps introducing further truth values, or changing the nature of the truth attribution from functions to relations, or even other alternatives. The point, again, is that the logical background available and the problem one has to face both generate a round of the bootstrapping method, and once a problem is formulated, there is an a priori search for the solution.

Let us now explicit the case of logic following the three stages of the a priori, according to Tahko, as numbered in the previous section, in a general setting. First, the bootstrapping relation requires that the system proposed on a priori terms faces the empirical evidence. This is still a bit difficult to settle, due to the lack of consensus on what counts as evidence in logic (see ([Hjortland, 2019](#)); ([Martin, 2021](#))). Independently of how we see it, the idea is that some evidence is available, and must be accounted for. A priori investigation on the field of possibilities would then indicate systems that may accommodate the recalcitrant derivation without trouble, some systems being fit for the purpose, some not (and this is in agreement with point (2), where we may scan the possibility of a theory that does not account for the case, it gets known a priori, but does not hold of the actual world). Finally, the only restriction on the field of possibilities is that we are searching for legitimate systems of logic, and characterizations of such systems are available. The delimitation of the legitimate candidate should not worry us: even if there are infinite possibilities, we rely on scientists' experience and good sense for the search of appropriate candidates (just

as in any other scenario in life). Perhaps some of the theoretical virtues favoured by the anti-exceptionalist can play a role in severely restricting the field of possibilities, perhaps a sort of pluralism is a natural consequence, this is a point for a different discussion.

It is important to mention that this new approach to the field of possibilities and our relation to it brings us closer to a view of logic as proposed in the linguistic frameworks by Carnap. We may describe the frameworks independently of choosing one of them as the appropriate one for the actual world (independently of whether one considers that such systems are describing semantic aspects of language, or structural aspects of reality). Choice is in a large measure a pragmatic matter that may also be fomented by experience (the bootstrapping process, of course). This also contributes to the possibility of a priori knowledge of pure systems of logic. Even if a system of logic is not chosen as appropriate for the phenomena in question, it still retains its status of a priori, just as Euclidean geometry, as discussed previously. Also, this view of the frameworks as linguistic, constituted by their own characterization rules, may be preferred by those worried by the use of ‘worlds’ in Tahko’s original approach, and is more akin to the characterization of logical systems in current literature. One may also prefer ‘models’, as in a logic as models approach (see ([Shapiro, 2014](#)); ([Becker Arenhart, 2022](#))), which would also deflate the metaphysical character of Tahko’s approach in a quite natural way. Again, a deeper discussion on this subject goes beyond the scope of this paper.

The bootstrapping process may be recognized as the moving force behind most of the proposals concerning the current proliferation of candidates to be the ‘right’ logic for dealing with human argumentation in natural language. It is interesting to think about syllogistic theory as a paradigmatic case. As advanced by Aristotle, it somehow incorporated the existential presupposition, i.e. the thesis that the concepts dealt with must have existent instances. This granted that going from ‘all S is P’ to ‘some S is P’ counts as valid (the relation of subalternation of the square of

oppositions), among other syllogistic inferences. Further consideration by Aristotle's followers, however, led them to judge that this is not really valid. In particular, the inference seems to have counterexamples; consider the inference 'all extraterrestrial living forms come from outside of planet Earth' to 'some extraterrestrial living forms come from outside of the planet Earth'. This requires that there are extraterrestrial living forms, which is not far from controversy, to say the least. This revision took traditional logic one step further, leaving the existential hypothesis behind.

Similar examples in more recent literature could proliferate. Consider, for one more case, the development of logic after Whitehead and Russell's *Principia Mathematica*. One of the suggested problems with the logic of the *Principia* is that it incorporates the *Principle of Bivalence*, which states that every sentence is true or false. One of the complaints raised by Łukasiewicz against it is that it clearly implies that human action is no longer free (and this is related to the problem of the future contingent, already pointed out by Aristotle). That is, after the establishment of a background knowledge, the system of the *Principia*, further a posteriori considerations seem to suggest (at least to Łukasiewicz) that problems appear. An additional set of a priori reasoning, exploring the possibilities to solve the problem, led him to a three-valued system, which he advanced as the appropriate alternative to deal with this issue. Also, a generalization of the idea led him to many valued systems in general, not all of which are claimed to be true of the actual world. They are possibilities not actualized, or perhaps thought experiments in the field of logic.

4 Advantages of the bootstrapping process

In this section, we list some of the advantages that the bootstrapping relation between the a priori and the a posteriori may bring to an anti-exceptionalist view of logic.

To begin with, just as ([Hjortland, 2019](#)) has already advanced, the idea that

a particular system of logic must be chosen taking into account the evidence does not, by itself, privileges classical logic. In other words, for all we know and accept as evidence in favour of a system of logic so far, it is not immediately clear that classical logic is the winner. The bootstrapping process is neutral on which logic must be chosen as applying in this world (independently whether it is one logic or many, see the next topic). This should be clear due to the fact that the kind of evidence that must be used in the bootstrapping process is just the same that the anti-exceptionalist is already willing to countenance.

It should be clear then, that the bootstrapping process, as amended by us, does not add more weight to any system in particular, and does not decide in favour of a single system (*pace* Tahko, who sees a form of law of non-contradiction as a basic constraint on the possibilities; this is an issue we shall not discuss here). What is needed for the process to run is an established background knowledge, a kind of accepted system, even if provisional, that will have to face further evidence. It is generally thought that the background logic we have, the accepted logic, is classical logic. It could be any other logic which one considers to be a good candidate for the appropriate logic for a given goal. Once that is settled, one may look for evidence that the system works, and also for evidence that the system does not work. In general, these evidences are in the form of a mismatch between the inferences allowed or not allowed by the system, and the inferences that look *prima facie* as valid outside of the system. They will make the process run again, or will have to be accommodated in the system with some kind of explanation. This is very much in agreement with the actual understanding of how logic face evidence in the anti-exceptionalist camp.

As a second major feature of the bootstrapping relation in logic, one could hold that it is independent of the disputes on whether there is one, many, or no system that applies correctly in this world. When one considers the canonical application of logic, concerning human reasoning in natural language, and thinks that a system must account for that, then, the bootstrapping process is neutral, as a process, as to which

of the mentioned positions should hold. Decisions on these issues depend on how to evaluate a system and how it accounts for the evidence. That is, one may think that a single system accounts for all kinds of inferences, as far as it is the appropriate system ([Routely, 1980](#)), or think that many systems do that, generating a form of pluralism (see also ([Bueno, 2002](#))). That would mean that distinct possibilities examined a priori account for the problems we find in the field of argumentation (i.e. that distinct possibilities are the case in the actual world). Notice that nothing prevents also a form of relativism, where evidence is partitioned into domains, so that distinct systems may account for distinct domains (see ([Shapiro, 2014](#)), for instance).

For a further advantage of the process of bootstrapping over current anti-exceptionalist epistemology, one could mention that it helps us explain the practice of logicians much better (*pace* ([Martin, 2021, 2023](#))). First of all, adopting the bootstrapping view it becomes clearer how typically logical modelling process is performed. One may select some salient component of experience (an application) and revise some of our current available systems (which constitute part of the background information available) to conform to them. This is typically performed independently of whether this system is adopted as the finally true one; sometimes it is advanced merely as a kind of thought experiment or toy model, to attempt to account for specific features of some entailments that are supposed to hold. Some of the proposals do not even have such a direct relation with experience. Consider theoretical questions such as the existence of implication connectives satisfying *modus ponens* in many-valued paraconsistent logics. At first, no application of the system to deal with inferences in natural language is claimed. There is a background knowledge involving paraconsistent systems, implication, and a problem to get a system with an implication having determined features (see also ([Molick, 2021](#)) for an account of this process). Exploration of the field of possibilities leads one to answer the question, and one may clearly be said to obtain knowledge about such systems. The current epistemology of anti-exceptionalism, on the other hand, centered on logical theory choice, cannot

account for such cases (again, see ([Becker Arenhart, 2024](#)) for a discussion). One ends up ‘knowing’ that some rule is appropriate or that some proposition is valid only if the rule or proposition is part of the selected system. This leaves us without an explanation of logical knowledge of many systems that are not actualized. The bootstrapping process, as we mentioned, can easily handle these cases.

This point is important enough for us to emphasize it. Anti-exceptionalism, as currently advanced in the literature, and due to its focus on a posteriori evidence and distrust on a priori methods, ends up equating logical theory choice with logical epistemology. We can only have knowledge of logical laws and logically valid inferences as far as they are part of the system that is actually chosen as the best one, as accounting for the evidences, even if only for the time being. The process of bootstrapping allows that systems are discovered in the field of possibilities, and still, are not adequate for the actual world (or, perhaps, are not even considered as serious candidates for the actual world). This does not prevent us from having a priori knowledge of them (see ([Priest, 2013](#))). Pure logic, as a field of mathematics, then, is also allowed for; this specific scenario is just not accommodated by current anti-exceptionalist epistemology. Tahko advances the point as follows:

If alternative, non-actual geometries are a priori, that is, they were reached by a priori means in the manner described above, then surely they are still a priori, regardless of the fact that they are not actual. In other words, merely possible a priori propositions, branches of the tree of knowledge that turn out not to correspond with actuality, are a priori nevertheless. This is presumably true of Euclidean geometry as well, insofar as it is internally consistent. Empirical information can only establish the truth or falsity of an a priori proposition in the actual world (and even this is fallible), but the proposition has its a priori status by necessity. If this is correct, then Euclidean geometry as well as the phlogiston theory and a great number of other such abandoned theories are still very much a priori,

albeit merely possible. (Tahko, T. E., 2011), p. 163-164.

In this sense, logics, as pure systems, do not get falsified by experience. This is important, because Euclidean geometry, as a pure system, was also not falsified by experience. The approach advanced here, then, makes better sense of mathematical practice.

Notice what this does not mean: this does not imply that logicians (mostly in philosophy departments), while discussing the most appropriate system, do not use evidence of natural language to argue for their systems. As (Priest, 2016) and (Martin, 2021) argued, the process of dispute over a most suitable logic can be seen as one similar to the process of theory choice as described by anti-exceptionalism (the abductive method). What we are claiming is that this is not everything there is to the epistemology of logic. In actual *logical practice* there is also formulation of frameworks, knowledge of pure logics, and study of abstract systems *per se*, advanced independently of issues concerning the adequacy or correction of such systems (see also the claims in (Franks, 2015)). These dimensions of logical investigations are not covered by current anti-exceptionalist accounts of the epistemology of logic.

As a final advantage of the bootstrapping relation, one that may be questioned by some, we find it that the method *allows* (but does not impose) for us to consider that logic, as far as it is used to deal with argumentation, may be understood as applied mathematics. As pure mathematics, it is known a priori, and is not the least damaged by the fact that the actual world does not behave as the theory predicts. As applied mathematics, it may be seen as involving idealizations and abstractions that are not perfectly suited for a phenomenon such as natural language reasoning. There will always be some adjustments and, as adjustments, they may require a theory revision, or perhaps, only more flexible treatment of data. That is, the bootstrapping method allows that a less crude relation between theory and reality be adopted, and that one recognize that logic is mathematics, and as such, will sometimes (perhaps most of the times), involve elements that are strange to the actual world.

The anti-exceptionalist methodology, as currently understood, does not seem to allow for such elements. Fit with the data is part of the method of theory choice, which, as we mentioned, is equated with the epistemology of logic. By distinguishing the dimensions of theory choice and logical epistemology, we aim to open better prospects for the involvement of idealization and abstraction. Although this is not the place to discuss this topic in detail (again, see ([Becker Arenhart, 2024](#)) for further discussion), we should mention why we believe that equating epistemology and theory choice is problematic, even if only superficially. The first problem concerns the idea of choosing a theory by abduction: in that case, theories must account for the evidence that is already assumed as justified. In most discussions, evidence in logic is assumed to come from intuitions, which are a traditional epistemic source of justification (we are not saying it is not problematic). If not coming from intuition, still, some other source of justification must be present anyway. That is a place where an epistemology is needed before the theory choice process is apt to run, so that a conflation of theory choice and epistemology is not warranted. The second problem concerns the very scenario where theory choice is a problem in philosophy of science: when we have several candidates accounting for the same evidence, but which advance different and incompatible descriptions of reality. In those cases, abduction enters the stage to take some pragmatic virtues into account. Related to the first problem, one must already have the evidence to be explained well established. This is just not what happens in the case of logic. Here, disagreement is not concerning details, but it already enters when it comes to explaining what the data is. Proponents of rival systems do not start with the same data as requiring explanation. In such scenarios, abduction cannot really work as a neutral method for gaining knowledge; it rather works as a more or less biased way to choose the logic one is already inclined to prefer.

5 Conclusion

We have advanced the claim that logic may be seen as being a priori even in the context of logical anti-exceptionalism. What we find in the literature is the statement that anti-exceptionalism requires that logic be a posteriori, due to its similarity to empirical science. While this may help us to understand the process of logical theory choice, it helps very little when it comes to understanding the proper epistemology of logic. According to this view, we gain knowledge of logic insofar as we select the most appropriate logical theory.

The proposal advanced here is an extension of Tuomas Tahko's bootstrapping view of the relation between a priori and a posteriori reasoning. It has the advantage of providing epistemic status to what is actually done in logic, even for those theories that are not applied to the actual world, and allows that experience plays a role in theory choice. By requiring that we examine the field of possibilities disengaged from constraints of immediate applicability, it allows us to account also for the actual practice of logicians. What logicians typically do is to select some inferences that are considered as valid or salient in a given form of discourse, and attempt to provide for a system of logic modelling these inferences. They also try to make corrections in already existing systems which allegedly fail to account for valid inferences. All of these may be understood as involving an a priori incursion in the field of possibilities, and eventually a subsequent selection of one of the systems as legitimate for the case in hand (see also the discussion in ([Tajer, 2022](#)) and ([Becker Arenhart, 2022](#)) for related claims displacing the idea that 'correctness' is the ultimate goal in logical theorizing). System development and system selection are separated and distinct processes.

We believe that anti-exceptionalism should have nothing against the bootstrapping method, given the role of experience in both views. Also, it is an advantage of the bootstrapping method to open a place in anti-exceptionalism for knowledge of systems

of logic that do not apply to the actual world, or do not attempt to apply to it. This is an important aspect of the current practice of logic, and any philosophical account of the epistemology of logic that does not include it is incomplete. As we mentioned, the great emphasis of anti-exceptionalism on theory choice ends up restricting the epistemology to applied systems. The bootstrapping methodology solves the problem with great advantages. Overall, the view developed in the paper poses a new challenge for the anti-exceptionalist: either logic is a priori and aligned with science, or logic is not a priori but does not reflect scientific practice and the development of scientific knowledge.

Certainly, more can and must be said if the method is to make clear the role of logic in each possibility, and whether issues such as impossible worlds, trivial worlds, and the such are allowed as available fields of incursion for logic problem solving, accessible a priori from our background information. However, we believe that this paper is the first step in this direction, and these issues will be investigated in the future.

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