

Can Başkent *Editor*

# Perspectives on Interrogative Models of Inquiry

Developments in Inquiry and Questions

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Volume 8

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Editor

# Perspectives on Interrogative Models of Inquiry

Developments in Inquiry and Questions

 Springer

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# Preface

Hintikka's theory of interrogative models of inquiry is the starting point of this volume. Interrogative models of inquiry (IMI, for short) present an interesting take on various epistemic issues including Socratic *elenchus*, learning theory, abductive reasoning, social choice theory, and nonclassical and modal logics. This relates IMI very closely to a variety of different fields, and this relation is perfectly well displayed by the articles in this volume.

It is important to note that Hintikka's contribution to logic and formal epistemology is usually clouded by his work on other fields, such as epistemic logic and game semantics. Perhaps for this reason, IMI does not seem to be very popular among researchers. One of the goals of producing this volume is to change this tendency by showing that IMI has influence on many different subfields in logic and formal philosophy.

This volume also demonstrates it very clearly that IMI in itself is a very rich theory. Helping in understanding its (current) depth and breadth, the volume includes both technical and logical articles as well as conceptual and analytical work.

In short, there are three main goals behind producing this volume: (i) showing that IMI heavily relates to a wide variety of fields in logic and philosophy, (ii) underlying the centrality of IMI in Hintikkan thought, and (iii) showing the breadth and depth of the field. I leave it to the reader to judge how much we managed to achieve our goals.

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The volume opens with Hakli's article on inquiry and justification. Hakli's account argues as to how Hintikkan interrogative theory can unite inquiry and justification. The second paper, by Genot and Gulz, carries the debate over to learning theory. At first glance, the connection between the learning theory and IMI is clear, yet Genot and Gulz develop the connection further by resorting to various game theoretical elements. Then Angere, Olsson, and Genot take an interesting step and introduce formal epistemological and social choice theoretical issues to the discussion. They focus on jury sizes and use Bayesian methods to present

an analytical solution. In my own article, I suggest that Hintikkan inquiry and Lakatosian method of proofs and refutations share some common themes, which interestingly include both of them being inconsistency-friendly. This paper relates IMI to nonclassical logic. Van Bendegem's article considers mathematical practice and its connection to problem solving which can be seen as a Hintikkan inquiry. Antonelli presents a formal application of defeasible logic to IMI and suggests two different approaches. Urbański and Wiśniewski's article reminds us of the Socratic roots of Hintikkan epistemology and in particular of IMI and presents an elaborated formal structure. Hamami's article relates IMI to a quite broad field of dynamic epistemic logic and presents an axiomatic system for dynamic logic of interrogative inquiry. Naibo, Petrolo, and Seiller discuss an important epicenter of Hintikkan epistemology and introduce a novel philosophical perspective from a computational angle.

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The volume originated within the framework of a research project which was funded by the French National Research Agency (ANR, *Agence Nationale de la Recherche*). The project was conducted at IHPST (*Institut d'histoire et de philosophie des sciences et des techniques*) which is a research institute affiliated with CNRS and the University of Paris 1 Panthéon – Sorbonne. During its two-year lifespan, I was employed at the project for one year in 2012–2013. The project produced two international workshops and conferences, numerous monthly seminars, research visits, conference participations, and a variety of research articles. Once the project came to an end, there already has been established an international network of researchers who were heavily influenced by Hintikka's philosophy and willing to share their expertise. This volume can be considered as an output of this network.

For this project and the volume, I am grateful to many people. Gabriel Sandu, who first developed the idea behind this project, was helpful in every stage of the project; hosted me and Yacin in Helsinki, and even organized a lunch for us with Hintikka himself. My colleagues Francesca Poggiolesi, Yacin Hamami, and Henri Galinon were always there when I needed some help and assistance. I am also more than thankful to our anonymous reviewers who helped us immensely with their feedback and guidance.

My deepest special gratitude is for Marco Panza, the director of the project, who encouraged me immensely for producing this volume. The idea of making this book belongs to him. Without him, this volume would not have existed.

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Finally, I hope that this volume will serve as a bridge between Hintikkan theory of interrogative inquiry and the researchers working on similar fields and show that there is still a lot left to be worked on.

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# Inquiry and Justification

Raul Hakli

**Abstract** Traditionally, inquiry and justification have been treated as two distinct phenomena that are largely independent of each other. Seeing both as interrogative processes can help to see how they are connected. Inquiry is seen as such in Hintikka's model of interrogative inquiry, and justification is seen as such in the dialectical account of justification. It is argued that processes of inquiry and justification are not independent of each other: On the one hand, successfully carrying out processes of inquiry may require engaging in processes of justification. On the other hand, processes of justification may require engaging in processes of inquiry. Production of scientific knowledge requires both types of processes.

**Keywords** Interrogative inquiry • Epistemic justification • Dialectical justification • Scientific knowledge

## 1 Introduction

This essay will study the connections between scientific inquiry and epistemic justification. Traditionally, justification and inquiry have been seen as two quite distinct phenomena that are largely independent of each other. Justification has been a central concern of analytical epistemology, in particular, for the analysis of knowledge which is usually taken to require justification. Inquiry, on the other hand, is often associated with discovery of knowledge and has been more of a concern of philosophy of science. To an extent, these two lines of research have been isolated from each other.

In philosophy of science there is a traditional distinction between contexts of discovery and contexts of justification, which not only indicates that inquiry and justification are separated from each other but also suggests that they should be

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kept so separated. It has been thought that coming up with theories or hypotheses is different from assessing the extent to which theories or hypotheses are supported by available evidence.

The focus of philosophy of science has been on activities that concern production of scientific knowledge whereas the focus of epistemology has been on analysis of knowledge and on evaluation of alleged instances of existing knowledge. Activities of knowledge production include steps of discovery, reasoning, and accepting hypotheses. Justification plays a role in them, but its focus is on evaluating steps of reasoning and assessing evidential relations between data and hypotheses. In mainstream epistemology, justification has been important because traditional analyses of knowledge have taken justification as a necessary criterion that beliefs must satisfy in order to count as knowledge. Attempts to spell out exactly when somebody's beliefs are justified has led to an abundance of theories of justification (see, e.g., Lamménranta 2004).

There have been attempts to shift focus of epistemology from justification of beliefs to questions of inquiry. Jaakko Hintikka (2007) criticises epistemologists' preoccupation with justification and claims that studying how to acquire new knowledge is more crucial for epistemology than studying how to secure old knowledge. Provocatively, he suggests an "epistemology without knowledge and belief", in which traditional studies focussed on analysis of concepts of belief and knowledge have been replaced by a logical study of information acquisition.

Related criticisms can be found in the writings of philosophers who have been influenced by pragmatism such as Isaac Levi (2012) and Christopher Hookway (2006). Levi (2012, 1) notes in an approval tone that pragmatists like Peirce and Dewey were not interested in justification of beliefs but justification of changes of beliefs, that is, justification of steps of inquiry. According to Hookway (2006), epistemology is committed to what he calls a "doxastic paradigm", in which the focus is on beliefs and their evaluation. The epistemologists' primary interest is in the state of belief of an agent, not in the process of reasoning that leads to it. He argues for "epistemology as theory of inquiry", in which the target for epistemic evaluation lies, not in the justificatory status of our beliefs, but in our ability to successfully carry out inquiries. Also Bernard Williams (1973) points out that our main interest with respect to knowledge is in finding sources of reliable information rather than in examining whether somebody really knows or merely believes something that we already know, which has been the central concern in epistemology. The suggestion for epistemology, then, is to replace the viewpoint of an examiner with that of an inquirer.

While acknowledging the importance of inquiry, this essay suggests that inquiry need not replace justification in epistemology, but complement it. The aim is to argue that there are deep interconnections between inquiry and justification, and neither of them can be fully studied in isolation. Firstly, as Hintikka (2007, 19–20) noted and as I will try to argue in more detail below, inquiry is important even in the context of justification. This is so because in order to settle whether one is justified in one's belief or judgement, one may sometimes have to acquire new knowledge. It is not always enough to simply reflect upon one's evidence or to evaluate the

reliability of one's cognitive faculties. Sometimes, and this happens typically in scientific contexts, one has to come up with new experiments that can be used to confirm or disconfirm the content of the belief or the judgement.

Secondly, I would like to claim that inquiry is not independent of justification either. In order to engage in a successful process of inquiry, one needs to consider which assumptions and methodological principles are reasonable. In addition, in the course of inquiry there are several choice points that require assessment of different sources of information in order to select which of them to trust. These are questions that concern epistemic justification.

In order to defend these general claims, I will study two accounts or models of inquiry and justification, respectively. The model of inquiry I will focus on is Hintikka's Interrogative Model of Inquiry (IMI), which sees inquiry as a process of asking questions and drawing logical inferences from the answers received. I will give a brief description of the model in Sect. 2. In several places, Hintikka (2007, e.g., p. 3, 8, 22, 224) says that both inquiry and justification are accomplished by the same interrogative process. However, he does not state explicitly what is the nature of justification that the process is supposed to accomplish. What does the process of interrogative inquiry produce that justifies its results? There are several possibilities here because the nature of justification can be understood in several ways.

I will review some candidates in Sect. 3. My main thesis will be that the best way to understand Hintikka's claim is by taking justification to consist of being in a position to answer critical challenges. Such a view has been called the dialectical account of justification and it has been defended by several philosophers including David Annis (1978) and Michael Williams (2001). Even though this model of justification has not been developed to the same level of technical detail as the IMI, it could be called the Interrogative Model of Justification (IMJ). This is because according to the dialectical approach, justification, too, involves a process of asking questions and answering them. Seeing both inquiry and justification as inherently social processes that involve question-answering dialogues not only reveals analogies between them but it also shows that they are deeply interconnected. In particular, it shows how processes of justification may create a need for further inquiry. In Sect. 4, I will argue that processes of inquiry also create a need to engage in processes of justification. I will conclude by looking at the consequences of the presented views for the concept of scientific knowledge in Sect. 5.

## 2 Interrogative Model of Inquiry

The main idea in Hintikka's Interrogative Model of Inquiry is to reconstruct processes of knowledge acquisition as steps of logical reasoning extended with interrogative steps for obtaining new information. Such reasoning can be represented using tableau (or sequent calculus) systems in which the conclusion to be proved is on the right hand side and the initial assumptions on the left hand side. Using the rules of the system, complex formulas are broken into simpler parts, which

may involve branching. The goal is to show that the conclusion follows by closing all the branches in the tableau: If a formula and its negation appear in the same branch, or if the same formula appears both on the left hand side and the right hand side, the branch closes.

Hintikka extends the basic model by interrogative steps that are used for bringing in new information by asking an oracle a question. A question can be asked once its presupposition has been established. For instance, if in a branch we have formula  $A \vee B$  on the left hand side, we may consult an oracle and ask whether  $A$  is the case or  $B$  is the case. We then add the oracle's answer to the left hand side and continue the process. In the basic version of IMI, there is only one oracle and all of its answers are assumed to be correct and remain constant.

The basic version can be extended by allowing for uncertain answers or several oracles. Such extensions create the possibility of inconsistent answers. In cases of inconsistency, the inquirer must select which answers to accept. The answers that are not accepted at the current stage will still be represented in the tableaux, but they will be bracketed which means they will not be taken into account when applying rules, unless they are later unbracketed. A detailed exposition of the rules that define the deductive, interrogative and bracketing moves of the Interrogative Model is presented by Hintikka et al. (1999).

In addition to the above *definitory rules*, there are also *strategic rules* that tell the inquirer how to use the definitory rules in an effective way. The content of the strategic rules is left out of the model in order to keep it general: Different strategic rules can be used in different types of inquiries. In particular, which answers to bracket in order to keep the inquiry on secure grounds is an important strategic question, a question involving epistemic justification (Hintikka 2007, 20–21).

According to Hintikka (2007, 19), the various oracles can represent different sources of information, like nature (in the sense of providing results to experiments), human witnesses, research databases, the inquirer's own memory, or tacit knowledge. The reliability of a source can then be assessed by comparing the source's answers to the previous answers from the same source and the knowledge obtained from the other sources (Hintikka 2007, 214). Emmanuel Genot (2009) presents a bookkeeping method for keeping track of the answers given by different sources of information.

### 3 How Inquiry Produces Justification

Let us now consider how we should understand the nature of justification in light of Hintikka's idea that inquiry not only produces scientific discoveries, but also justification for these discoveries. The variety of existing theories of justification gives many possible options to select from. For instance, according to reliabilist approaches, one's beliefs are justified just in case they are produced by reliable processes. One might claim that processes of inquiry generally produce reliable results: Inquiry is a process that systematically eliminates epistemic alternatives, or

possible worlds, in light of obtained information, and the remaining alternatives are then the ones that are not ruled out, so we are justified in thinking that the actual world must be among them.

However, this may not be the right way to think of justification at the level of generality of the interrogative model of inquiry. This is because reliability crucially depends on the strategic rules that we use during the inquiry. In particular, it depends on our theoretical assumptions and our policies to rely on certain sources of information. If the reliability of the process depends crucially on their reliability, then the process itself cannot guarantee reliability. It does not guarantee that the actual world is not among the worlds eliminated. (This is not to say that reliability cannot play an important role in comparing different methods of inquiry in which the strategic rules are fixed.)

I suggest instead that the general capacity of the process of interrogative inquiry to deliver justification lies in its capacity to provide reasons for the conclusions acquired. Even if such inquiry cannot guarantee reliability it can guarantee that there are reasons for the way the elimination was carried out. Assuming that the process of inquiry can be reconstructed by using the IMI, these reasons are, furthermore, represented in an explicit and communicable form. The interrogative model provides the inquirer immediate reasons for an accepted proposition in the form of the premisses from which the conclusion was derived or of information concerning the sources (together with the strategic judgement that these sources can be trusted). And if these reasons are not enough to convince someone who challenges the accepted proposition, one can trace the reasoning all the way back to the initial assumptions.

But there are still several theories of justification that take the existence of reasons as a necessary ingredient of justification, in particular, foundationalism, coherentism, and infinitism. Which one should we choose if we want to integrate justification and inquiry in the way that Hintikka seems to suggest?

According to foundationalism, an agent's belief is justified if and only if either the belief is a so-called basic belief (these are taken to be "given", "self-justified" or something similar) or the agent has other justified beliefs that serve as reasons for the belief. This model of justification would fit well with the IMI only with the additional assumption that the premisses from which the inquiry starts are basic beliefs. This is a substantial assumption, however, since the choice of premisses is a strategic choice left open by the model.

According to coherentism, an agent's belief is justified if and only if it is a part of a coherent network of beliefs which mutually support one another. While the process of inquiry certainly provides support from the premisses to the conclusions, the reverse direction is not guaranteed. In IMI, the direction of support follows the direction of reasoning which is from premisses to conclusions, as in foundationalism. Thus, inquiry does not seem to produce justified conclusions in the sense required by coherentists.

Finally, according to infinitism, a belief may be justified by an infinite chain of reasons, but this idea is very difficult to reconcile with the IMI because the model does not allow for reaching conclusions by infinite chains of reasoning. It thus seems

that none of these theories fit very well with Hintikka's view that inquiry produces justification. Let us turn to an alternative theory that seems better suited for the purpose.

According to the dialectical account, in order for an agent's acceptance of a proposition to be justified, the agent must be able to respond to other agents' appropriate critical questions and challenges by providing reasons for the judgement. This is in stark contrast to standard individualistic theories like evidentialism and reliabilism that take justification to be a function of agent's evidence or of the reliability of the agent's cognitive processes. Similarly, foundationalism, coherentism and infinitism are individualistic theories because they only consider the agent's internal mental state. In the dialectical approach, the criteria for justification depend not only on the agent's internal states and her relation to external environment but on the social relationships between the agent and other agents, more specifically, on an interrogative process in which the agent answers questions posed by others. The agent not only needs to have reasons for her view, she must also be able to articulate those reasons and be prepared to defend them in response to criticism: Justification requires that one is in a position to justify one's views to others.

How far an agent has to go in providing reasons depends on the social context: Once the agent has given reasons for her view the challenger may ask for further reasons to accept these reasons. This may continue until the process reaches such beliefs that have a *default justification*. Such beliefs can be challenged further too, but only in so far as the challenges themselves are backed up by positive reasons to doubt the beliefs with default justification (Williams 2001). Which beliefs enjoy the default status and which rules govern appropriateness of challenges depend on the epistemic context in which the dialogue takes place. In science, the context is provided by the discipline: Certain disciplines (or research paradigms to use a Kuhnian term) are committed to certain methods and principles that are usually taken for granted when doing research. A researcher working within a discipline and presenting her results is assumed to be able to defend her specific assumptions and the ways she has conducted her experiments but she need not normally be prepared to defend the general assumptions that are shared in the community. These are only to be doubted if there is specific reason, for instance, in cases of puzzles and anomalies that may eventually reveal the inadequacy of the shared assumptions of the discipline. When accumulated, such problems may lead to the assumptions being revised or abandoned in favour of some other assumptions.

Note the parallelism with the Interrogative Model of Inquiry: There are definitory rules saying that if one accepts something, others are entitled to challenge it by asking for reasons and one will then have to be able to provide acceptable reasons or retract the claim, unless the proposition enjoys default status in which case it is the challenge that needs further support. In addition, there are strategic rules that specify which propositions enjoy default status and which challenges are appropriate. This is a very general model of justification that can be applied both in everyday conversations and in scientific debates in different disciplines. Similarly to the IMI, it leaves open the strategic rules, which here govern default status and criticism that one can present against a given view. These depend on the epistemic reason-giving

practices of the relevant epistemic community. (As in the case of methods, all of this is consistent with the possibility that different epistemic practices could also be assessed in terms of their reliability.)

This parallelism is not the reason why this model of justification fits so well with the IMI, however. The reason is that this model of justification explains what it is in the interrogative process of inquiry that produces justification. As a result of the process, the inquirer has, in the form of a tableau or a proof tree, an explicit representation of the reasons that support the inquirer's conclusion: The premisses, the steps of inference, the various sources of information, and hopefully also the strategic rules guiding the inquiry. This information puts the inquirer in a very good position to defend her results against possible challenges. When a conclusion is challenged, the inquirer may give reasons for it by saying that the conclusion follows by application of such and such a rule from such and such propositions that she also accepts. Or she may say that the conclusion was as an answer to such and such a question by such and such an oracle that she, in accordance with her strategy of inquiry, takes to be a reliable source. These replies may again be challenged in which case the inquirer may have to review the chain of reasoning further, possibly all the way back to her initial assumptions. Assuming that she has relied on theoretical and methodological assumptions generally accepted in her epistemic community she will be able to provide reasons for her own results and point to the direction of the external sources in cases in which she has relied on testimony.

Of course, the possibility remains that the critic is not satisfied with some of the inquirer's assumptions. The critic can question some of the theoretical assumptions by pointing out to error possibilities that the inquirer has failed to take into account. The critic can also question some of the methodological assumptions, which may or may not be explicitly stated by the inquirer: They may be explicitly formulated strategic rules but in practice they may be merely habits and conventions that are tacitly or even unconsciously followed during the process of inquiry. Critical questioning can bring such implicit research heuristics into light and force them to be articulated into explicit strategic rules. (Of course, the model itself makes some assumptions like the use of classical logic. Also the selection of the language in which the inquiry is carried out is an assumption that could in principle be questioned.)

A situation in which an assumption is questioned creates a need to acquire new information, which can be modelled in the Interrogative Model of Inquiry by starting a new tableau with the questioned premiss as the conclusion to be proved. Since contested assumptions are rarely redundant, they usually cannot be proved from the remaining premisses alone without consulting oracles for additional information. Thus, the need to justify assumptions creates a requirement to come up with new experiments or sources of evidence. In order to successfully complete the process of justification, a new process of inquiry must be carried out first.

The part of questioning the inquirer's assumptions and strategies is not as such accounted for in the standard Interrogative Model of Inquiry. Even though the model allows the inquirer to ask the oracle further questions, the structure of the oracle's epistemic state is left outside of the model. An interesting extension then would be

a multi-agent—or a multi-inquirer—version in which the agents sometimes take the role of an inquirer asking questions and sometimes the role of an oracle answering questions and justifying their results to other inquirers. This kind of a model with multiple inquirers with different disciplines with their own assumptions and strategic rules would provide a model of science as a social activity of epistemically interdependent inquirers.

## 4 How Inquiry Needs Justification

As we have seen, inquiry produces justification for its conclusions. Of course, this may not always be the purpose of inquiry. Sometimes inquiry may be used for pure discovery in which case the strategies of inquiry are different: The goal is not to maximise reliability of the results but perhaps their novelty (see Kiikeri 1999). Still, one purpose of inquiry is to produce scientific knowledge, which conceptually requires justification. Hence questions of justification are present in inquiry as well: Justification of the conclusions obtained in inquiry depends on the justificatory status of the assumptions and the reasoning steps of the inquiry.

Justification of assumptions is a problem, because the requirement to have secure grounds for knowledge quickly leads to scepticism. We have learned from Descartes' method of doubt that very little can be known without making any assumptions. Science would not get off the ground if we were supposed to prove the existence of the external world before being able to do empirical inquiry: In order to study the world, an inquirer must assume there is a world to be studied. A Cartesian sceptic pointing to the error possibility that scientists have overlooked, namely that there might not be external world, would not be taken seriously in science, because scientific justification is not foundationalist in nature. That there is an external world can be seen as a "hinge proposition" (Wittgenstein 1969) that is necessary to assume in order to be able to gain knowledge about the world. The dialectical account of justification provides a more accurate picture of the structure of justification in science because it contextualises the question of which assumptions can be taken for granted to the type of the inquiry in question. In certain contexts, for instance in some fields of research, certain assumptions are collectively accepted as legitimate in that field. The assumptions are not dogmatically believed but provisionally accepted. They enjoy the default status of justification in that field and can be relied on as long as there is no positive reason to doubt them. In other fields, however, they might need to be scrutinised. Even Cartesian sceptical hypotheses can receive serious consideration in philosophical studies.

The same kind of contextualism may apply to the justification of steps of inquiry as well: In different fields, different reasoning methods may apply. For example, in many empirical fields, there are standard statistical methods for data analysis that serve as reasons to accept the conclusions drawn by the scientists. These methods are typically not questioned in these fields but are justified by default. If somebody asks a question about the methods of data analysis, it suffices to give a reference to



a standard statistics textbook. However, statisticians, mathematicians, philosophers, computer scientists and others interested in foundations of statistics may certainly question the validity of standard statistical methods and develop alternative ones. In contexts of inquiry focussing on methodology of statistics, the standard methods do not have the default status because it is precisely their justification that is under study. If sufficient reason to question the standard methods emerges from these debates, these reasons may be transferred to discussions in the empirical fields and legitimise questioning the use of the standard methods there as well, thereby overriding their default status.

Another salient point in which justification is needed in the context of the Interrogative Model of Inquiry is in the strategic choice of which oracles to trust: Whose answers to accept and whose to bracket? One possible answer is to consider the track record of the oracles' previous answers (Hintikka et al. 1999): In order to decide whether an oracle's answer should be accepted we should see how well its previous answers have been in line with what is known from other sources. However, there are problems with this suggestion. One obvious problem is that we may not have a complete track record of a particular oracle available. And even if we had one, it only tells about past history, not about the current case. Accepting the answer given by the oracle based on its previous successes brings in the usual difficulties involved in inductive inference. Moreover, there is a problem similar to the generality problem often discussed in the context of reliabilism that some instances of the oracle's previous answers may not be relevant for estimating its reliability in this particular case. Consider the case of scientific experts, for instance; the oracle may be reliable on certain subject matters but not on others.

In the context of IMI, there is a more fundamental problem of using track record data to estimate the reliability of a source. This concerns the feature of the model that all information that is not assumed prior to the process, comes from oracles: Thus there is no independent source of information that could be used to verify answers obtained from oracles, only other answers obtained from oracles. Therefore, a track record can only be made relative to other answers but there is no principled way of saying which answer should be taken as the correct answer against which to compare the other. If an answer by an oracle differs from its previous answers, how do we know whether the oracle has forgotten or learned, that is, whether it is now making an error or whether it has gained more knowledge and now gives more accurate information? Or if an answer of one oracle differs from an answer given by another oracle, how do we know which one to trust? We cannot say that we should trust the one that we have found to be more reliable because their reliability is exactly what we are trying to find out.

Of course, in case of conflicts, we may always ask yet another oracle. However, there is no guarantee that we will be better off by just adding new oracles. Even though methods that rely on finding out a majority opinion may sometimes help, they make substantial assumptions about the reliability of the sources. For instance, according to the famous Condorcet Jury Theorem, if the sources are independent of each other and each source is more likely to give a correct answer rather than an incorrect one, then the answer of the majority will approach certainty when new

sources are added. However, if the sources are generally unreliable then the majority will most certainly give us false information.

It seems that we are running in circles: In order to investigate the reliability of sources we need to have estimates of their reliability prior to the investigation. Of course, we typically do have prior estimates and we do prioritise certain sources over others: A naturalist may prioritise nature, a rationalist may prioritise reason or intuition, a phenomenologist experience, a theist holy scriptures, and so on. The point is that the model does not offer any guidance as to how these estimates are arrived at: The evaluation of sources is left as a strategic choice for the inquirer.

However, there is another way of assessing the oracles' answers, and that is justification understood in the dialectical sense discussed above. Upon receiving an answer from a particular source, we may ask the source for reasons for the answer. This does not resolve the theoretical problem that information only comes from oracles but it at least provides some principled ways of assessing sources. As Miranda Fricker (2010) has noted, the ability to support claims by offering reasons is a crucially important indicator property that helps the inquirer to distinguish good informants. In the case of nature we may perhaps not be able to ask for reasons directly but we may at least make more experiments to test the answer. In the case of human testifiers, we can ask how they know the answer or what makes them think it is correct. In the case of research reports and other literary sources, we expect to find descriptions of the experiments and other evidence supporting their results. In any case, if we want our inquiry to produce justified conclusions we should make sure that the sources we rely on are justified in theirs. The best way to find out is to interrogate them for the reasons they have for accepting the conclusions. Eventually, our aim is to find out whether we can integrate their results with our own inquiry, whether we can commit to the assumptions and methodological principles that have guided their research. If we can, then we may decide to accept their answers and rely on them in our own investigation. But if we doubt their conclusions, premisses, or methodological principles, and they cannot provide satisfactory reasons for them, then we may wish to bracket their answers and consult other sources.

Of course, we do not always go very far in asking for reasons, but the integration remains an ideal, especially in cases of collaborative research in which group members try to achieve knowledge together. Sometimes we are not even in the position to evaluate or understand the reasons that others have for their conclusions, and we can only rely on their expertise. This creates epistemic dependencies in which the reasons supporting one's conclusions are distributed over several sources (see Hardwig 1985). This dependence is illustrated by viewing inquiry and justification as interrogative processes.

Justification therefore enters inquiry on many levels. In fact, it can be suggested that questions of justification are inherently present in every stage of scientific practices, from choice of methods and basic assumptions to selection of questions to study, instruments to use, experiments to make, datasets to analyse, and so on. The justificatory principles that guide researchers in all these decisions may not come from highly general and idealised theories of rationality and justification studied in traditional epistemology. Rather they concern whether the decisions

can be convincingly argued for to other researchers in the field sharing similar background assumptions. The aim of researchers is not to demonstrate infallible results following from absolutely certain first principles. Rather it is to produce well-argued but defeasible conclusions from reasonable background assumptions that are considered fruitful and maybe shared by other researchers in the discipline but only provisionally accepted.

The combination of interrogative model of inquiry and the dialectical model of justification illustrates the close relation between inquiry and justification but it still leaves room for seeing them as distinct activities. Even though questions of justification are present in every step of inquiry, inquiry can be seen as a process of searching for conclusions which combines forward steps of reasoning and interrogation and backward steps of revising strategies, bracketing and unbracketing previous steps represented in the tableau. Once the inquirers are satisfied with the current stage of the tableau, they will be able to assert their conclusions by constructing an argumentative line in which the various bracketed sidesteps are ignored. Typically this will then be used as the basic structure for a research talk or a written publication that is delivered to the scientific community in an argumentative form that exhibits the conclusions as justified in the form required by the dialectical principles: It presents the conclusions as backed up by reasons derived from principles and methods assumed to enjoy a default status of justification together with results obtained from oracles, that is, experiments and previous research, which are documented in accordance with generally accepted principles. A critical reader should then be able to find replies to challenges that may rise and sources for previous research that the study builds on. Should the critic find the reported evidence wanting, she may present her criticisms, but again in an argumentative form that provides reasons to doubt the alleged results.

This is why scepticism has no bite in science. The claims made by scientists are not meant to be absolute but conditional in nature: These are the results arrived at using these methods given these assumptions. Neither the Pyrrhonian sceptic who continues to ask for reasons beyond the generally accepted assumptions nor a Cartesian sceptic who says that there is a logical possibility that the assumptions may be false will be able to raise a positive reason to doubt the assumptions. Since they are not prepared to make any commitments themselves, they will not be able to argue that an alternative hypotheses might be more plausible than the ones made by the inquirers. Only other inquirers will be in a position to do that. If they are successful, revisions will be in place. The self-correcting nature of science follows from the interdependence between inquiry and justification: Inquiry aims to start from reasonable, default-justified premisses and to proceed by reasonable steps using acceptable principles in order to produce justified conclusions that survive critical scrutiny. However, sometimes the conclusions turn out to be problematic, in which case we may need to go back and revise or bracket some of our assumptions or the answers we have received from oracles. Justification in scientific context does not depend on static support structures between premisses and conclusions. Instead, science is a continuous self-correcting enterprise consisting of social processes of inquiry and justification continuously interacting and influencing each other.

## 5 Conclusions: Producing Scientific Knowledge

We have seen that, on the one hand, inquiry requires justification because its ultimate aim is to produce scientific knowledge, because scientific knowledge requires justification, and because the justification of the produced knowledge depends on the justification of its premisses and its methods. On the other hand, justification requires inquiry because justification is a product of inquiry. Moreover, processes of justifying one's conclusions may also create a need for inquiry because when an agent is trying to defend her views dialectically, it may turn out that existing evidence does not support them to a sufficient degree. Hence, more evidence is needed to settle the issue, which thus suggests new experiments and avenues of further inquiry, eventually leading either to finding stronger evidence for one's results or a revision of one's starting points and improvement of the theories.

Given the dialectical approach to epistemic justification and Hintikka's model of inquiry, both justification and inquiry can be seen as social activities in which agents dialectically pose questions and give answers to them. The picture that emerges displays science as a collaborative enterprise in which scientific knowledge is produced. Individual agents sometimes take the role of an inquirer in pursuit of new knowledge asking for questions and making challenges and sometimes the role of an oracle answering questions and justifying their results to other inquirers who are asking questions and making challenges. Various special sciences differ in their methods and practices, but it can be argued that they all share a common structure consisting of steps of reasoning and inquiry together with argumentative principles governing epistemic justification and knowledge production. The combination of the interrogative model of inquiry and the dialectical model of justification suggested here aims to model that shared structure. Anything more specific than that may demand detailed empirical study of actual scientific practices in specific disciplines if the target is a descriptive model, or substantial methodological recommendations if a prescriptive model is sought for.

This picture also illustrates the nature of scientific knowledge: It depends on theoretical and methodological assumptions which may sometimes have to be corrected in order to meet critical challenges. Dependence on assumptions does not lead to scepticism, however. We may still have knowledge, it is just that our knowledge is conditional in form. We may know that from these premisses and these methodological assumptions these conclusions follow. This is the form of scientific knowledge, and at least in principle, in the ideal case in which all the assumptions made explicit, it can be certain. It may turn out that one of the premisses or assumptions was not justified, or even that it was false. Still the conditional claim was and remains a piece of scientific knowledge. It is just not very interesting piece of knowledge once its antecedent turned out to be false, so we need to make corrections to our assumptions and inquire further.

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