QUANTIFIERS, QUESTIONS AND QUANTUM PHYSICS

Essays on the Philosophy of Jaakko Hintikka

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Foreword and Acknowledgements

Jaakko Hintikka is one of the most creative figures in contemporary philosophy. He has made significant contributions to virtually all areas of the discipline (with the exception of moral philosophy) from epistemology and the philosophy of logic to the history of philosophy, aesthetics and the philosophy of science. In our view, part of the fruitfulness of Hintikka's work is due to its opening important new lines of investigation and new approaches to traditional philosophical problems.

In this volume we have gathered together essays from some of Hintikka's colleagues and former students exploring his influence on their work and pursuing some of the insights that we have found in his work. While the book does contain some criticism of Hintikka's views, this certainly does not purport to be a fair and balanced look at his work. We are unabashedly partisan in our admiration for the man and his work and have put this volume together in a collaborative spirit as a celebration of Hintikka's many contributions to philosophy.

In this volume we have included an annotated bibliography of Hintikka's work. We gratefully acknowledge the *Philosopher's Information Center, The Philosopher's Index* and Dick Lineback in particular for permission to reprint some of the abstracts included in the bibliography. By itself, this would serve as an important resource for philosophers and scholars. 'Prolific' is too modest an adjective for Hintikka, as readers can see for themselves from the size of this annotated bibliography. His massive and diverse body of work poses a real challenge for scholars who hope to find a single philosophical agenda or view that we can associate with Hintikka.

D. Kolak and J. Symons (Eds.), Quantifiers, Questions and Quantum Physics, pp. 1-2.

300+ articles, many of them groundbreaking, overwhelm and in a certain sense eclipse his 35+ books. There are a number of ways that one can approach the scale and variety of this work. Our purpose in including the bibliography is to permit others to glean what they will from Hintikka's prodigious philosophical output. We eagerly anticipate the publication of a current bibliography of Hintikka's work, including all reprint and translation details in the *Library of Living Philosophers* volume dedicated to Hintikka. That task, unfortunately, was beyond us. Heartfelt thanks also to Anthony E. Nelson for expert assistance with the grueling task of typesetting.

When we considered the importance and impact of Hintikka's work, it occurred to us that its philosophical consequence is not the additive property of the sum of its parts. We struggled for a way to think about the proliferation of research programs, counterarguments and Ph.D. dissertations that Hintikka's work inspires and settled in the end on the awkward analogy of the powerset. Hintikka's philosophical legacy will be something like the philosophical powerset of his publications and lines of research. The powerset of a set S, is the set of possible subsets of S, and by analogy, rather than attempting to synthesize Hintikka's work into well-defined themes or bumper-stickers, our goal here is to represent the proliferation of different ways one can construe his work and the variety of lines of inquiry that it suggests.

We are very grateful to the distinguished group of colleagues who have contributed to this volume. We are a diverse group, from recent students of Hintikka to some of his most distinguished peers. While we are far from agreement on all the issues discussed in this volume, we are all united by a great fondness for this remarkable man. We see him as a central and pivotal figure in our individual and collective pursuits of wisdom.

Anyone who is even remotely aware of what Hintikka may be working on at the moment will have the impression that his next greatest achievement, his next greatest result, is just down the road ahead of us, just around the next bend. Those of us who have the privilege of knowing Hintikka cannot help feeling the intensity and excitement of philosophical discovery. Unlike so many of the cynical, world-weary philosophers who figured so prominently in recent decades, Hintikka's energy, optimism and mental agility are unparalleled. In that respect, he is the most refreshingly immature mature philosopher in our midst. To put it simply, among philosophers Hintikka is youngest at heart, and boldest of mind.

Daniel Kolak and John Symons

THE RESULTS ARE IN: THE SCOPE AND IMPORT OF HINTIKKA'S PHILOSOPHY

Daniel Kolak and John Symons

Jaakko Hintikka is more like a scientist or a mathematician than most philosophers in that his greatest contributions derive less from his views than from his results.[60] Hintikka, probably more than any other major philosopher, works at the intersection of traditional philosophical questions and the technical results of mathematical logic, physics, neuroscience and computer science.[61] In this respect, he is sometimes compared with the great American philosopher W.V. Quine. However, there are many significant differences between the two. While Quine has admitted to regretfully having produced no major contribution to real logical theory, Hintikka brings his mathematical creativity to bear directly on philosophical questions, using logical techniques to reach philosophical results that, once they are understood, are as extraordinary as his technical results are indisputable.

There is another related difference between Hintikka and Quine that helps illuminate Hintikka's unique place in contemporary philosophy. Most readers recognize that Quine's philosophy is shaped by his commitment to the all-encompassing metaphysical framework of philosophical naturalism. By contrast, if there is an all-encompassing framework that future readers will associate with Hintikka's work, they will find it as one of the conclusions, rather than as a premise of his many investigations. Hintikka's philosophy is driven principally by what he can prove. This makes reading Hintikka difficult (if satisfying) work. The lack of any obvious and familiar big-picture assumptions is an obstacle facing many of his readers, but it also makes his philosophy less of a defensive action in support of a particular view and more of a progressive accumulation of insights. Unfortunately, Hintikka has been impatient to explain the philosophical import of technically-driven results to philosophers who may not be able immediately

[60] In saying this, we are to a certain extent modifying Hintikka's own occasional claims to have adopted a kind of Kantianism. While, the question of the relation between Hintikka's and Kant's philosophy is quite fascinating and well worth further attention, we do not believe that much light is shed on Hintikka's work merely by seeing it through the lens of Kant's transcendental philosophy. To the contrary, in our view, such an interpretation may (and indeed, often does) serve to conceal some of the more radical aspects of Hintikka's philosophy. Since arguing this point here would require us to defend a reading of Kant in addition to Hintikka, we leave this matter for another occasion.

[61] Thus as Wiebe van der Hoek notes in the *Knowledge, Rationality & Action* special issue of *Synthese*, "Epistemic logicians in computer science acknowledge Hintikka as their origin," (Volume 139, **2**, March 11, 2004, p. v).

to grasp them. (As one of us recently put it: "What the machinery conceals is what the machinery reveals."[62]) Hintikka's reluctance is not due to modesty on Hintikka's part but through the sheer doggedness of his devotion to inquiry. He has rarely engaged in retrospective consideration or explanation of his work as a whole because, as he often says to friends and colleagues, there are too many other interesting things to work on.

Often, Hintikka will end an article or a lecture by introducing a new line of inquiry or a new set of open questions rather than settling on some easily digested philosophical conclusion. Hence, our task in this essay is to make the philosophical import of his work as clear as possible. It is difficult to do justice to Hintikka's results, while at the same time making them accessible. Sometimes we have found that by beginning with some analogy to a point in the history of philosophy, some remark from Aristotle or Leibniz on modality, Peirce on language or quantification, we can see more clearly what Hintikka might be up to. Our strategy in this essay is to begin in the relatively familiar territory of the history of philosophy, mentioning the way some of Hintikka's technical insights figure into his reading of history, before embarking on a more detailed exposition of some of those results.

Section One begins by sketching some of the main features of his approach to the history of philosophy. We can only examine a selection of prominent cases where his technical work is set in dialogue with his interpretation of his predecessors. Hintikka's reading of Aristotle's logic is probably familiar to most philosophers, but we will also discuss some of his less famous studies of Newton, Hume and the Bloomsbury Group. These are likely to surprise readers familiar with Hintikka's work and are, in some ways, more representative of his approach to history than, for example, the more prominent work on Descartes' Cogito argument. The historical topics we discuss in Parts One and Two are (with one exception) those which we can directly connect to our more technical overview of Hintikka's work later in this essay. We hope thereby to reinforce our claim that Hintikka's historical discussions are by and large continuous with his technical work. We hope also to show that his systematic work illuminates, and in turn is illuminated by, his forays into the history of philosophy.

Hintikka's contributions to the philosophy of language have been quite prominent. However, to get a clear sense for the general import of his work in this field, it is useful to see the interplay of historical scholarship and technical investigation. His views on language and ineffability are a clear case where he mixes a reading of the history of early analytic philosophy with a set of theses concerning the nature of logic and semantics. In Section

[62] Daniel Kolak, *On Hintikka* Belmont: Wadsworth.

for future work, to provoke some critical reaction and to highlight the many deep and interesting open questions that Hintikka's work poses.

1. HINTIKKA ON THE HISTORY OF PHILOSOPHY

Hintikka has been criticized for engaging with the work of great historical figures as though they were his contemporaries. There is a sense in which the charge of anachronism inadvertently gets to the heart of what is most interesting about his historical investigation. Critics are right to remind us that Hintikka's approach to the arguments and ideas of his predecessors bears little resemblance to what usually falls under the rubric of "the history of ideas." Rather, his historical inquiry is unabashedly continuous with his purely conceptual work. The refinement of central concepts and methods in the history of philosophy is integral to Hintikka's program of redrawing the traditional notions of analysis, induction, intuition and the principle of plenitude to name but a few. Especially noteworthy are his interpretations of Plato, Aristotle, Descartes, Leibniz, Peirce, Husserl, Hilbert, Wittgenstein, Tarski, and Gödel, about whom and from whom he has drawn important insights.

Traditionally, inquiry into the history of ideas involves analysis of the context and content of technical terms, their corresponding concepts, and the role they play in the views of the particular schools or traditions of a period. For instance, historians might track the social and moral influences that acted on certain key players or they might work to understand the role of key ideas against the intellectual backdrop of philosophical periods and movements.

By contrast, Hintikka is less an historian of ideas than an expositor of the development of ideas *qua* ideas, viewed quite independently of the particular philosophers with whom they are associated or the historical events within which or out of which they can be viewed as emerging. Hintikka's approach is premised on the idea that the history of philosophy is practiced most fruitfully by philosophers. While one can disagree with Hintikka as matter of historiographical principle, it is difficult to deny that when great philosophers read the history of philosophy *qua* philosophers, it is likely to lead to interesting results.

A revealing example of Hintikka's approach to the history of ideas is his interpretation of the origins of formal logic itself. For Hintikka, Aristotle's logic is the result of an investigation into the nature of questioning and specifically of a reflection on the nature of Socratic *elenchus*. In Socratic *elenchus* answers are (at a certain point) clearly necessitated by the interlocutor's response to earlier questions. In some sense, according to Hintikka, the necessity of an inference originally derives from its place

within an interrogative context. This sequence of necessary answers to questions can be represented formally via Aristotle's syllogistic logic and, according to Hintikka, this was precisely the original purpose of the syllogism. The syllogism then is a notion that appears as part of a general theory of questioning. Essentially, Aristotle saw logical and scientific reasoning as occurring within an interrogative framework rather than as an abstracted process of deducing propositions from premises.

Of course, the interrogative approach to logic has been central to Hintikka's own systematic work for many years and so this aspect of his interpretation of Aristotle is clearly filtered through technical observations in that endeavor. This is not the place to get too far into the details of his reading of Aristotle, however a sympathetic reader can find a great deal of textual evidence in its support. For instance, in *Posterior Analytics* (A vi, 75a 22-27), after having laid out the necessary steps in the process of scientific reasoning, Aristotle seems to confirm Hintikka's claim that even in what appears to be a strictly deductive context, we are still within an interrogative framework:

> Yet one might perhaps puzzle why we should ask questions...when the conclusion is not necessary; for one might as well ask any chance questions and then say the conclusion. [The answer is that] we must ask the question not because what is asked is necessary, but because necessarily whoever says them says them, and says something true if it is true.

Aristotle can be read as emphasizing that not all steps in a scientific questioning process are implied, in a strictly deductive sense. Hintikka draws on similar passages in defense of his interrogative interpretation of Aristotle.[64] It is beyond the scope of this essay to take sides for, or against the interrogative reading of Aristotle's logic. However, as we discuss the details of Hintikka's interrogative approach to logic in later sections, it is worth keeping the good Aristotle in mind. Better historians than the present authors are likely to see that even if Hintikka is only partially correct, it is likely to lead to significant changes in the way we understand Aristotle's philosophy.

[64] See for example his "Socratic Questioning, Logic, and Rhetoric," Revue Internationale de Philosophie 47, (1993), 5-30 and more directly his "On the Development of Aristotle's Ideas of Scientific Method and the Structure of Science," in *Aristotle's Philosophical Development: Problems and Prospects,* William Wians, editor, Rowman and Littlefield, Savage, Maryland, 1996, 83-104. There you will find the textual evidence for the interrogative reading of Aristotle's logic.

Unlike his more recent essays on Aristotle, where Hintikka's own results are enlisted in an effort to rethink the history of philosophy, his papers on Leibniz and Aristotle from the 1960's show Hintikka drawing on the history of philosophy in order to form a clear picture of necessity and possibility. Especially noteworthy in this respect are his "Leibniz, Plentitude, Relations and the 'Reign of Law'," [65] as are his many essays on Aristotle's conception of modality from the 1960's early 1970's.

Returning to cases where Hintikka is applying technical results to historical considerations, we find another important example in his reading of Frege and Russell on the supposedly unavoidable ambiguity of the word "is." By applying game-theoretical semantics to natural languages, Hintikka shows that we do not need to live with this apparent ambiguity. Frege and Russell thought otherwise, which is why they built the machinery necessary to handle the distinction into their logical notation.[66] Hintikka shows decisively that—in spite of Russell's claim that this is the greatest advance in logic since the Greeks—we do not have to distinguish the *is*es of identity, existence, predication and the general conditional (subsumption). In some cases it is quite impossible to make the distinction in any natural way. Different uses of *is* are distinguished not by reference to different meanings of the operative word but by reference to context. Hintikka's systematic approach to the logic of ordinary language reveals that the traditional or received logic of quantifiers from Frege and Russell is not the only possible model of the semantics of natural language nor is it the most faithful. We will have more to say about this below.

Hintikka's attention to the fit (or failure thereof) between ordinary language and received first-order logic has a number of other important consequences and has served as an important argumentative strategy in much of his work. One prominent case in point is Hintikka's criticism of Chomsky's use of conventional logical form as a representation of the logical form of natural-language sentences. Were Chomsky's account of the nature of quantification in natural language correct, we would be compelled to conclude that no generative methods can fully account for the acceptability of English sentences.[67]

[65] "Leibniz, Plentitude, Relations and the 'Reign of Law'," *Ajatus* **31**, (1969), 117-144.

[66] See Hintikka's paper, "'Is,' Semantical Games and Semantical Relativity," *Journal of Philosophical Logic* vol,. 8 (1979), pp. 433-468, reprinted in *Paradigms for Language Theory and Other Essays*, vol. 4 of his *Selected Papers*.

[67] See for example "Quantifiers in Natural Languages: Some Logical Problems II," *Linguistics and Philosophy* **1**, (1977), 153-172, and "Quantifiers in Logic and Quantifiers in Natural Language," in *Philosophy of Logic. Proceedings of the 1974 Bristol Colloquium*, Stephan Körner, editor, Basil Blackwell, Oxford, 1976, 208-232. Quantifier phrases behave in natural languages rather like other denoting noun phrases. This fact is not accounted for by using the

Returning to the history of philosophy, if one approaches the work of pre-Fregean philosophers with Hintikka's criticism of the ambiguity thesis in mind, it will actually change how one reads one's predecessors. After all, prior to the 19th century the Frege-Russell ambiguity thesis played no significant role. However, since this thesis is built into our received elementary logic, common applications (by most philosophers and historians of philosophy) of the received logic to pre-nineteenth century work are both dubious and misleading. Why then is our received first-order logic still used as grist for the mill of historians' and philosophers' interpretations of early modern, medieval, and ancient philosophies?

The anachronism of the Frege-Russell ambiguity thesis and, with it, our received first order logic, is not itself a condemnation of the application of logical and semantical analysis of the history of philosophy. Hintikka's work from the 1980's makes this clear, when for example he and Jack Kulas developed their game-theoretical semantics for English quantifiers and anaphoric pronouns.[68] This treatment relies in no way on the Frege-Russell ambiguity thesis and strikingly, the resulting theory is remarkably similar to Aristotle's theory of categories.

Many have been puzzled by Aristotle's wavering description of his categories: e.g. as widest genera and as etymological categories. Aristotle himself correlated the distinction by using different question words as labels of different categories; his verb for being, for instance, *einai*, is used differently in the different categories. Hintikka argues that Aristotle did not mean just one of these distinctions but rather, all of the above, because in a natural game-theoretical treatment of ordinary-language quantifiers such different distinctions must go together. Aristotle's theory of categories reveals the logical structure of ancient Greek and his categories are an ontological dramatization of this *Sprachlogik*.

To take another example, consider the *historical* development of the notion of induction, specifically, its role in the history and philosophy of science. For instance, many historians of science have found it strange that Newton claims to have derived or *deduced* the most general laws of physics from particular phenomena. Newton's methodology, after all, is strictly experimentalist, in that it relies on controlled experiments. Once we understand that among Newton's "phenomena" are outcomes of controlled

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usual first-order logic as one's canonical notation. Hintikka contends that a game-theoretical treatment explains the similarity: each quantifier phrase will denote one particular individual, but only relative to a play of a semantical game. Moreover, the values (denotations) of existential and universal quantifiers are selected by a different player.

[68] Jaakko Hintikka and Jack Kulas, *The Game of Language* Dordrecht: D. Reidel (1983) and Jaakko Hintikka and Jack Kulas, *Anaphora and Definite Descriptions: Two Applications of Game-Theoretical Semantics*, Dordrecht: D. Reidel (1985).

experiments and, moreover, that what Newton means by *induction* is not making inferences from particulars to general laws but, rather, *extrapolation*, *interpolation* and other combinations of partial generalizations, Newton's claim is made quite clear.

This, Hintikka suggests, has a certain resemblance to Aristotle's methodologically similar assumption that we each have immediate access to certain general truths in so far as we are capable of realizing the relevant forms in our own souls. Thus medieval nominalists, who gave up the Aristotelian idea of a full-fledged realizability of universals, did not have to resort to inductive inference; instead, they postulated suitable "innate ideas" in the mind, thereby demonstrating how it is possible to make up for a paucity of available answers to a given question by strengthening our initial premises. Hintikka's contention is that the problem of induction became a problem as such only after both the metaphysics of forms and innate ideas were discarded.

Not only was "Hume's problem" not a problem before Hume, the reason Hume had a problem to begin with stemmed from a misunderstanding of the nature of the experimentalist methodology in Newton's system. According to Hintikka, Newton did not rely on inference from particulars to general laws. Rather, his methodology presupposed the generalizations and consisted in the extrapolation, interpolation, and integration of already reached partial generalizations. Newton's notion of induction is a quantitative version of Aristotle's puzzling notion of *epagoge*.

Hintikka's historical work is not restricted to the philosophical literature in the narrow technical sense, but includes *belles-lettres*, theology, and aesthetics. This point is easily overlooked because Hintikka is known and admired for looking at the history of ideas from the vantage point of logic and epistemology. Nevertheless, both in his lectures and in a few of his publications, his broader attention to the role and evolution of philosophical ideas outside technical philosophy is revealed. Consider, for instance, his essays on the Bloomsbury intellectuals, whose titles alone reveal quite a bit of the story: "The Longest Philosophical Journey: Quest of Reality as a Common Theme in Bloomsbury" (1995), and "Virginia Woolf and Our Knowledge of the External World" (1979).

Moore and Russell claimed, famously, or infamously—depending on your metaphysical presuppositions—that we *do* have direct access to reality in virtue of the fact that in an experience we can, at least in principle, distinguish the experience as an event in your consciousness, from the object of this experience. The object experienced is not merely subjective. Rather, it belongs, or better to say *is part* of reality in Moore and Russell's view. What, then, are the "objective objects," given to you in different kinds of experience? Hintikka explains a parallelism between, on the one hand, the quest by Moore and Russell of the objects of perceptual experience and, on

the other hand, the search by Bloomsbury's art theorists for the basic objects of aesthetic experience.

This search is illustrated by Rickie, the protagonist of E. M. Forster's *The Longest Journey*. Forster's novel opens with a parody of sophomoric Cambridge philosophy undergraduates questioning the reality of external objects: does the world exist when I do not perceive it? Does the cow? As the novel unfolds we discover that this is in fact the theme of the novel; Rickie's story is a prolonged quest for immediate contact with fellow humans and the world, in brief, a quest for reality. What Rickie hopes to avoid is the stultifying effect of conventional social norms and institutions, including conventional marriage and family life, which separate him from others. Forster sometimes described the effect of the kind of marriage that Rickie manages to avoid as being like an "astonishing glass shade" that falls between the couple and the world. Rather than facing the doomed longest journey towards death in an unhappy marriage – to echo the original home of the phrase in Shelley's *Epipsychidion* – Rickie rejects exclusivity in favor of immediate and unrestricted connection with other people.

The members of Bloomsbury were desperate to 'connect' with the world without the intrusion of any kind of mediating factors. Hintikka suggests that knowledge by acquaintance, in Russell's sense, has the same basic character. When Rickie reaches his goal, he finds that life has a new and refreshed meaning, "Because, as we used to say at Cambridge, the cow is there. The world is real again. This is a room, that is a window, outside is the night —." This sentence, Hintikka points out, is almost a paraphrase of G.E. Moore's (in)famous "proof of the existence of the external world" before the British Academy where he held up his hands and said, "This is a hand that is a hand, hands are external objects, hence the external world exists." The search for the objects of immediate awareness is part of the Bloomsbury Group's overall quest for authenticity and immediacy.

Likewise, in his other "Bloomsbury" paper, Hintikka reveals parallels between Russell's construction of the physical world in *Our Knowledge of the External World*, consisting in the experiences of real and possible observers, and Virginia Woolf's construction, through her fictional characters' stream of consciousness, of fictional worlds. These and other such essays by Hintikka are examples of how his rendering of philosophical problems, ideas and concepts reaches well beyond the narrow limits of technical philosophy.

As we turn in earnest to some of the technical details of Hintikka's work in logic and semantics, we will return to some of the historical claims touched upon here. For now, we are merely pointing to some of the highlights of Hintikka's conceptual engagement with the history of philosophy. We have, of course, left most of Hintikka's historical work out of our story. In fact, we have omitted his two most prominent historical

studies, namely, his performative reading of Descartes' Cogito argument and his extensive work on Wittgenstein.[69] However, a comprehensive survey of this kind is well beyond the scope of this essay.

2. NO EXIT? HINTIKKA AND THE LIMITS OF LANGUAGE

Hintikka's view of the nature of language is informed by a significant distinction between two contrasting views of the relationship of language, reality and human knowledge. While the distinction goes back to Leibniz's contrast between two different projects in logic, namely, *lingua universalis* vs. *calculus ratiocinator* it was articulated in its most influential modern form by Jean van Heijenoort in his paper, "Logic as Language, Logic as Calculus."[70] Unlike Leibniz and van Heijenoort, Hintikka calls these two contrasting views either *language as the universal medium* vs. *language as calculus* or sometimes the idea of the *universality of language* and of the *model-theoretical view of language*.

These terms are anything but self-explanatory. By "universality" in e.g. "language as the universal medium," Hintikka does not mean some universal features of actual languages. He means, rather, a kind of "inescapability." For the universalist, language is an "iron curtain" between reality and us. We cannot avoid the medium nor can we change it by means of language for the simple reason that everything we say already presupposes the meanings of our language. We thus cannot by-pass the iron curtain and, as it were, speak to what is on "the other side." As such we are simply incapable of seeing how language is related to nonlinguistic reality.

Readers should recognize immediately the Kantian and Wittgensteinian quality of this universalist view. Symptomatic of the universalist conception of language are, for instance:

1) the continuing fascination in certain philosophical (and broader) circles with the notion of ineffability
2) the rejection of metaphysics as nonsense

and

3) the failure of the broader philosophical community to recognize the usefulness of model theoretic techniques in philosophy.

[69] See e.g. Chapter 8, "Hintikka's Wittgenstein," in Daniel Kolak, *On Hintikka*.

[70] van Heijenoort, Jean, 1967: 'Logic as language and logic as calculus.' *Synthese*, vol. 17, pp. 324-330.

The core of the received universalist conception is the view that the semantics of a language is inexpressible in that language. And because meaning relations of a language are inexpressible in that same language, the crucial semantical concept of *truth* is indefinable. That is, according to idea of language as the universal medium, the notion of truth applied in your working language cannot be defined in that language. Consequently, universalists have great difficulty accepting any sort of correspondence theory of truth. Just as seriously, a universalist cannot describe how meaning relations of his or her language might systematically vary. Since the fundamental idea of model theory is the study of what happens as a consequence of such variation, we can see why, according to this view, model theory has little to contribute to the philosophy of language. For universalists, there simply cannot be any systematic model theory for ordinary discourse. We thus cannot speak about any but our actual world in our language, since trying to speak about some other possible world would presuppose a linguistic shift in the references of our expressions. Consequently, we have to speak as if only the actual world were relevant to our language and its semantics. Nor is there a place within a universalist position for the notions of metalanguage or metatheory. This is what Hintikka dubs the "one-world view."

For a universalist, then, logical truths are truths about the actual world, not about all possible worlds, as Leibniz or Carnap supposed. Russell expressed the same point by saying that the truths of logic are as much about the constituents of reality, i.e., the actual world, as are the truths of zoology, the only difference being that they are a good deal more abstract than are the birds and bees.

Thus, to take another example, Wittgenstein defends the ineffability of semantics in the *Tractatus*, without subscribing to the one-world-view. What he does is to adopt instead the lesser, but not unrelated, view that when we speak of different states of affairs we are nevertheless in each case speaking of the same objects, in so far as all possible states of affairs consist in the same simple objects, the same "substance." Tarski similarly showed us the means for defining truth for explicit first-order languages using a richer metalanguage, providing us with a model theory for such languages while at the same time denying the possibility of our ordinary, "colloquial" language having any consistent notion of truth

Since, for the universalist, the semantic aspects of language cannot be discussed in language and hence cannot be theorized about, the universalist is forced to cultivate a syntactical, i.e., purely formal, study of language. This, in spite of the fact that some universalists, most notably Wittgenstein, suggest definite relations between language and reality. These relations, a proponent of the language as calculus view could argue, make it possible for

us not only to speak, but to provide us with something to speak about, within well defined limits. As such, they surely form the basis for precisely the kind of theorizing that the universalist wishes to block.

The alternative view, "language as calculus", can be understood as a view which embraces precisely those lines of inquiry deemed impossible or illegitimate in the universalist view. However it must be kept in mind that by the phrase "language as calculus" we should not be read as endorsing the notion of language as an *uninterpreted* calculus. Rather, according to this view even our interpreted language, like a calculus, is freely re-interpretable.

The definitive source for studying this fundamental contrast between two opposing philosophies of language is Hintikka's second volume of selected papers, *Lingua Universalis vs. Calculus Ratiocinator* (Kluwer, 1997). Here Hintikka demonstrates and explains how the universalist view has dominated analytic philosophy for well over a century, and why it held sway over Frege, Russell, Wittgenstein, Quine and Church. For a while it held in its grips the entire Vienna Circle, as evinced by their preference for what they dubbed the "formal mode" of speech vs. the "material mode." Chomsky's preference for syntax over semantics may well be another case in point. Gradually, however, logicians were inspired by the various advances contained in Gödel's incompleteness theorems to move beyond the universalist bent for the primacy of syntax. Attempts to force even these theorems to purely formal and computational frameworks persisted for a number of years, but eventually the calculus or model-theoretical view has gained more philosophical respectability, while earlier defenders of the then unpopular calculus view, such as most notably Charles Peirce, have of late grown in stature.

Although Hintikka's publications on the universalist vs. calculus views are focused on the analytic and pragmatist traditions, his broader understanding in relation to the so-called continental philosophies are well known by his students and followers, whom he has inspired to build philosophical rapprochement. Martin Kusch, for instance, one of Hintikka's students, has applied Hintikka's distinction brilliantly to illuminate historical differences in the continental tradition. In his *Language as Universal Medium vs. Language as Calculus: A Study of Husserl, Heidegger and Gadamer* (1989), one of the most significant bridges between the analytic and continental traditions of the past several decades, Kusch dramatically illustrates how different philosophical stances toward Hintikka's distinction helped shape the development of phenomenology since Husserl.

The illuminating distinction between language as a universal medium and language as calculus exemplifies Hintikka's fusion of historical and systematic analysis. The two ways of understanding language have clear parallels at the level of what might seem to be dry and abstract logico-epistemological results. By examining the conceptual situation in the

technical context, we can arrive at a precise and clear way to understand and take a principled stand on one of the grand themes in Twentieth Century philosophy.

Some of the best evidence for the universalist view was once thought to be Tarski's theorem showing that explicit first-order language can only be defined in a richer metalanguage. Since no metalanguage beyond or above our actual working language exists, it was widely believed that our applied "colloquial language" cannot provide a definition of truth, such that the semantics of our own language is to a great extent bound to be inexpressible. But now Hintikka's IF (independence friendly) logic, as we shall show in Section Four below, has illuminated the reason Tarski's result holds: Tarski restricts his analysis to languages with an arbitrarily restricted logic. As we shall see, by overcoming this artificial restriction on first-order logic, Hintikka's technical advances help establish the case for the "language as calculus" view. The implications of this shift are significant. For example, in "Contemporary Philosophy and the Problem of Truth" (1996), Hintikka contends that the expressibility of semantical concepts such as "truth in the same language," renders hermeneutical approaches to language and thought unnecessary.

Similarly, Hintikka's systematic criticisms of Quine (e.g. "Three Dogmas of Quine's Empiricism,"[71] and "Quine's Ultimate Presuppositions,"[72]) illustrate the broader consequence of Hintikka's perspective for ideas currently central to the work of many leading Anglo-Saxon philosophers. First is the one-world assumption, according to which "the only purpose of our factual discourse . . . is to represent things as they are in this one actual world of ours," which Hintikka's analysis contends is, on the one hand, far too ontologically ambitious and, on the other, too naively realistic. English speaking (and thinking) philosophers who, like Quine, know only the "real world" know of it very little, as Hintikka quotes Kipling's famous lament: "What do they know of England who only England know." Hintikka's serious point, which he makes light of, is that we cannot do justice to our epistemic practice if we insist on using logic as if there were but one all-comprehensive domain of discourse. It is important to point out too that what blocked realistically interpreted modal logics for Quine was none other than this one-world assumption.

Another important Quinean commitment that comes under critical scrutiny is what Hintikka calls the "atomistic postulate." This is the notion that the input of information into an epistemic system will always take the form of particular, quantifier-free truths. According to Hintikka, if we

[71] *Revue Internationale de Philosophie,* 1997.
[72] *Theoria,* 1999.

actually examine the formation of scientific theories or even simple informal claims to knowledge, we will find that the "atomistic postulate" is not only defective but misleading. The problem with the atomistic postulate is that it grossly misrepresents actual scientific practice, where nature's answers to our questions—Hintikka's apt characterization of the experimental method—take the form of results from controlled experiments. The results of controlled experiments, as Hintikka argues persuasively, offer a counter-example to the atomistic postulate, since there is no to express them without including some reference to generality. We will have much more to say about the atomistic postulate below.

The fourth Quinean notion that Hintikka criticizes is the view that logic, in the sense of formal inference relations, plays the role of holding our theoretical structures together. If one drops a purely syntactical conception of logic and cognition, then Quine's web of belief must be made of stronger stuff than mere rules for the transformation of schemata. Hintikka has argued that logical relations between propositions cannot be reduced to formal rules of inference. And in a sense, this lesson can already be drawn from Gödel's incompleteness theorems. Quine's attempt to understand logical inference purely formally or schematically runs counter to the entire model-theoretical tradition in logic. One could reject the model-theoretic tradition but, in doing so, one would need to ignore the fact that Gödel's incompleteness theorems seem to make the model-theoretical approach indispensable.

3. HINTIKKA'S EPISTEMIC LOGIC

Hintikka is best known among philosophers, logicians and computer scientists as the creator of modern epistemic logic. His 1962 book *Knowledge and Belief: Introduction to the Logic of the Two Notions* has served as the basis for all subsequent work in this important field. Originally, epistemic logic simply involved the addition of an epistemic operator K to ordinary first-order logic. The relatively formal nature of this work should not be disconnected from what Vincent Hendricks calls "the epistemological ambition of the early Hintikka."[73]

The semantics of this supplemented first-order logic are modal in nature insofar as to talk about what a person knows is to specify a set of possible scenarios. This space of possible scenarios is divided between those that are compatible with what an agent knows, and those that are not. This is a relation between a knower *a* in the scenario *w*1 and those scenarios that are compatible with everything the knower knows in *w*1. *a* knows *S* in *w*1 iff it

[73] See Vincent Hendricks *Forcing Epistemology*, forthcoming, Cambridge University Press.

is true that S in all scenarios w^* accessible to a from $w1$. w^* is the set of epistemic alternatives to $w1$ for a, they are what Hintikka calls a's knowledge worlds in $w1$. The epistemic operator Ka therefore functions as a universal quantifier ranging over all a's knowledge worlds. So, not only is one's attitude towards the notions of possibility and necessity important to one's view of epistemic logic, but perhaps even more importantly, the behavior and nature of quantifiers becomes appreciable in Hintikka's presentation as one of the most critical topics in the development of epistemic logic.

We will return to some of the details of the epistemic logic below. However, Hintikka's contribution to epistemology is not restricted to the development of a useful formalism. He has begun to rethink all of epistemology in a strikingly simple and intuitive manner. Rather than focus on traditional epistemological debates over various modifications to the justified true belief model, Hintikka has developed an approach that models knowledge-seeking and belief formation as a questioning process. In a sense this approach is not radically new, for it can be thought of as an updated version of the Socratic method of questioning. However, the approach allows analyses and applications in a completely precise manner once we have an explicit logic of questions and answers in place. A completely general logic of this kind has recently been formulated as a part of his "second-generation epistemic logic."

Hintikka is in the process of applying the resulting "interrogative model of inquiry" to different epistemological problems. In a series of papers that will appear within the next year or so, Hintikka will argue for the irrelevance of philosophers' notions of knowledge and belief to the actual processes of knowledge-seeking (See, for instance, his forthcoming "Epistemology Without Knowledge and Without Belief"). According to Hintikka, philosophers would benefit by adopting a more pragmatic approach to epistemological theorizing. We use the term 'knowledge,' he suggests, as an honorific label that we attach to information that we are entitled to act on. Information rather than knowledge is the stuff of epistemology, according to Hintikka and, in this new model, the notion of acceptance replaces that of belief.[74] Additionally in this recent work, Hintikka urges us to revise our view of the varieties and different uses of the notion of information (including its uses in computer science and neuroscience), the presuppositions of questions as revealing the presuppositions of inquiry, the presuppositions of answers as revealing the a priori element in empirical inquiry, the logic of experimental inquiry, the different senses of the notion

[74] See the brief abstract of his forthcoming paper on this topic in the annotated bibliography in this volume.

of induction, and the notion of explanation (including "how possible" explanation).

An especially intriguing application is to the famous theory of cognitive fallacies developed by Tversky and Kahneman. Hintikka has argued that the so-called conjunctive fallacy is not necessarily fallacious at all. He is extending this point to a general refutation of the Tversky-Kahneman theory, including the other alleged fallacies, especially the so-called base rate fallacy and including the Bayesian presuppositions of the theory. Another application of the interrogative model concerns the question whether omitting data in experimental science is always a violation of scientific methods.

Of course, what makes it difficult, if not impossible, to present the full scope of Hintikka's view of epistemology is that the most philosophically dramatic claims of his second-generation epistemic logic have not yet appeared in print. We have only been able to sketch some of that material here from lectures, conversations and some unpublished material. Again, Hintikka's forthcoming *Socratic Epistemology*[75] will provide a detailed and unified presentation of these developments.

This having been said, it should also perhaps be pointed out that, from a historical point of view, Hintikka's epistemological revolution in the making might seem so traditional as to be downright counter-revolutionary. Hintikka sees the entire knowledge seeking enterprise as a related series of questioning procedures put to different sources of information. Scientific knowledge is the quest for answers from nature in the form of observations resulting from controlled experiments. This is what Hintikka means when he calls his "the conception of inquiry as inquiry." Knowledge as inquiry means knowledge resulting from interrogation, modeled after the Socratic *elenchus*. The Socrates of Plato's early dialogues claims he asks people questions because he knows nothing. This usually leads, irony of ironies, to Socrates' interlocutors realizing their own ignorance. Perhaps it's not just misery but ignorance too that loves company. But in Plato's middle and late dialogues *elenchus* ceases to be subtly deconstructive and becomes often not very subtly constructive, as when Socrates strategically interrogates Meno's slave toward the expression of a geometrical truth. The model of knowledge-seeking as questioning is a natural product of the spirit of *elenchus*.

Aristotle's *Topics* and *On Sophistical Refutations*, systematic studies of the Socratic questioning games practiced in Plato's Academy, both used question techniques that included the search of the first premises of different sciences keenly tuned on the winning strategies. Just as every trial lawyer knows that success in questioning a witness depends crucially on being able

[75] Forthcoming with Cambridge University Press.

to anticipate the answers one is likely to receive, Aristotle according to Hintikka is drawing our attention to the art of predicting answers we might get in a questioning game played against various "oracles."

There is a class of answers that any rational person must give, answers that are logically implied by the same answerer's earlier responses. By enumerating the conditions on such answers and their relation to their antecedents, Aristotle discovered systemic relations of logical consequence. In this way Hintikka establishes his view that logic itself originated as result of the study of questioning games. One crucial difference from the traditional Socratic method is that Hintikka's method of questioning requires that the predetermined answers, which he calls logical inference steps, be clearly distinguished from genuine interrogative steps for the simple reason that even if they are responses to questions, what matters is not the interlocutor's identity or attributes but, rather, that the premises occur earlier in the dialogue. As Aristotle put it, *ad argumentum*, not *ad hominem*, is how we must judge our logical inference steps. But now one might wonder why, if the fundamentals of the interrogative approach has been with us so long, why has it not been perfected long ago? The reason is that to use it successfully, one must be armed with an explicit logical theory of questions and answers. No such theory existed before Hintikka's groundbreaking work on the subject.

We do not mean to imply that the logic of questions and answers has not been duly studied. Indeed it has, but without arriving at a satisfactory, fully general, theory. But what might one mean here by *satisfaction*? In this case, satisfaction presupposes solutions to such problems as concern the logical form of questions and the question-answer relation. In other words, there must be distinct parameters, clearly expressible in logical notation, of when a given response is in fact a fully satisfactory answer to a given question? Likewise, *generality* in this case presupposes our being able to analyze all the different forms of questions. That Hintikka has fully solved these problems with a fruitful theory is no less remarkable than the fact that we are presently forced to piece it together from various notes and writings primarily addressed to other subjects. Once again, Hintikka provides no full-scale systematic presentation.

The first step we must take is to approach the logic of questions and answers in view of the obvious truth that they are not statements, whereas our usual logic is one of statements. Here is how Hintikka suggests we solve this problem. We start by noting that questions are themselves primarily and essentially epistemic, insofar as a question expresses the purpose of our coming to know some particular truth. That is why the logical properties of questions is determined, by and large, by their epistemic aim expressed as such by the statement specifying the epistemic state which we want any

given answer to bring out. This Hintikka calls the *desideratum* of a particular question.

Consider, for example, the desideratum of the following question:

(3.1) Is Hintikka going to Paris, Helsinki, or Martha's Vineyard?

This question can be translated into the following statement:

(3.2) I know that Hintikka is going to Paris or I know that Hintikka is going to Helsinki or I know that Hintikka is going to Martha's Vineyard.

But of course, 3.2 is but an extraordinarily clumsy way of stating that

(3.3) I know whether Hintikka is going to Paris, Helsinki or Martha's Vineyard.

Now, what Hintikka terms the *desideratum* of the question,

(3.4) Who is the author of *Knowledge and Belief: Introduction to the Logic of the Two Notions?*

is

(3.5) I know who the author of *Knowledge and Belief: Introduction to the Logic of the Two Notions* is.

That is how Hintikka reduces the study of questions to the study of their desiderata, which because they are statements can be studied by using our usual traditional logical methods. Now, let us beware that desiderata differ importantly from their corresponding direct questions in the following crucial way: desiderata contain a subordinate question with "know," "knows," etc., as the governing verb, which means that the logic of questions and answers must be a part of epistemic logic.

As introduced at the beginning of this section, the original feature of Hintikka's innovation that went well beyond the scope of traditional first-order logic was the subscripted operator K_a. This operator corresponds, in ordinary language, to "*a* knows *that*." Hintikka's research program in epistemic logic strives to express other ordinary language constructions with *knows* as the main verb in terms of the K-operator. Unfortunately, because the agent-indicating subscript is not in the scope of the operator, Hintikka's innovative way of writing out the K–operator is potentially confusing. And to merely say, in response, that *it works*, fails to do it justice. It is important

to note that the K–operator does not in fact receive its meaning from its counterpart in ordinary discourse. More than that, Hintikka's way of dealing with the meaning of the K-operator is very straightforward and admits of an elegant formal treatment. In Hintikka's view, if you specify what Smith knows, you are thereby specifying the entire class of the *scenarios* compatible with what Smith knows, what Hintikka calls "epistemic b–alternatives" to the actual states of affairs. It will then be true to say that b knows that S if and only if S is true in all those alternatives, which corresponds quite well with what ordinary people mean when they say that someone knows something. His characterization of the key crucial concept of knowledge is explicit and well enough defined to serve as our basis for a full-blown logic of knowledge.

Epistemic logic does not solve all, or even most traditional epistemological problems. In fact, it quite explicitly leaves a number of questions open. This should not be read as a weakness of the formal treatment of the concept of knowledge; on the contrary, it actually helps us maneuver around some traditionally thorny problems, such as defining the class of scenarios compatible with what someone knows, itself tantamount to the problem of defining explicitly the concept of knowledge and related concepts. What Jones believes, for instance, likewise determines and is determined by the class of scenarios, called *doxastic alternatives*, compatible with everything Jones believes. The obvious key difference, of course, is that whereas knowledge is assumed to be true, beliefs need not be. This mirrors other similar sorts of pair relations, such as the necessary condition that the actual world must be one of its own epistemic alternatives but not one of its own doxastic alternatives, the distinction between the notion of information vs. belief, and so on.

Hintikka has not always made these points clear in his work, nor has he always been consistent about what he has said about these similar but different kinds of logic in methodological practice. Oftentimes he seems to imply that what he means is that realistic applications such as are involved in scientific reasoning revolve around epistemic logic rather than doxastic logic or the logic of information. This unfortunately is misleading with regard to his own interrogative methodological model of scientific reasoning, wherein he explicitly leaves open the possibility that some of the tentatively accepted propositions are not true. This means, rather revealingly, that what Hintikka must here have in mind is something quite different from the logic of knowledge. These qualifications and complications go some way towards explaining why Hintikka seems to prefer the term *information* to the term *knowledge*.

Hintikka's scenarios are what in common technical philosophical parlance is known as possible worlds, and the translation of the semantics of epistemic logic into a variant of possible-worlds semantics is rather

straightforward. The technicalities do not need concern us here, since the main problems and their solutions are more easily explained using the examples such as, for instance, *wh*-questions as exemplified by (3.4) and whose desideratum is (3.5). We can quite easily express this desideratum in Hintikka's K–notation as follows:

(3.6) $(\exists x)KA(x,k)$,

where A(x,k) is but shorthand for "x is the author of *Knowledge and Belief*." The reason that the subscript K has been omitted is that the particular knower is irrelevant, so that the naked K can be read "it is known that." It is of course assumed that the relevant values of the x are persons. The important point is to understand exactly what (3.6) involves, which is best seen by comparing (3.6) with (3.7):

(3.7) $K(\exists x)A(x,k)$,

which says that it is known that someone is the author of *Knowledge and Belief*, where as what (3.6) says is that it is known of some particular person, x, that it is x who wrote *Knowledge and Belief*. This, clearly, is what ordinarily we mean when we say that we know who the author of *Knowledge and Belief* is. And, clearly, although the meanings of (3.6) and (3.7) are both straightforward, from the point of view of possible-world semantics there is a striking difference between them. (3.7) says that in each epistemic alternative someone wrote *Knowledge and Belief*. (3.6) says that there is some particular individual *x* who in each alternative wrote *Knowledge and Belief*, which presupposes something not presupposed in (3.6), namely, that it makes sense to speak of the same individual in different scenarios or "possible worlds." This brings us to one of the most important points in Hintikka's approach not only to epistemic logic but more generally to any logic whose semantics involves possible worlds, namely, that unless we have somehow been given a principle of cross-identification—a principle that tells when the denizens of two different scenarios or possible worlds are identical manifestations, in other words, of the same individual—we cannot understand such a logic. Moreover, this requirement is relevant only in cases where these principles are not themselves consequences of the principles determining the references of our terms in different possible worlds. Hintikka's important result here is that *such a reduction of identification principles to principles of reference is not possible in our actual conceptual system*. This means, for instance, that proper names—our most firmly targeted singular terms—do *not* fix the identity of their references. If I do not know who Jaakko Hintikka is, there must be scenarios

among my epistemic alternatives in which the name "Jaakko Hintikka" refers to different people.

The necessity of cross-identification principles is shown, from a purely formal point of view, by the failure of some of the rules of inference readily found in first-order logic, such as the rule of existential generalization exemplified by an inference to (3.6) from a sentence having the form,

(3.8) KA(f,k)

where "f" is shorthand for, say, "the Finnish philosopher at Boston University." (3.8) says it is known that *Knowledge and Belief* was written by the Finnish philosopher at Boston University. However, if it is not known who the Finnish philosopher at Boston University is, (3.8) might be true while (3.6) is false. In all the relevant alternatives it is true that the Finnish philosopher at Boston University wrote *Knowledge and Belief.* But the Finnish philosopher at Boston University might be a different person in some of the different scenarios, such as for instance Georg Henrik Von Wright, and so since there is no specific person who is known to be the author of *Knowledge an Belief,* in order for us to be able to infer (3.6) from (3.8) we need an extra premise guaranteeing this identity, which can be expressed by (3.9):

(3.9) $(\exists x)K(f = x)$

which says, in English, "It is known who the Finnish philosopher at Boston University is."

The relationships just expressed have a clear counterpart in the theory of questions, answers and their presuppositions. (3.7) is the presupposition of (3.4), the question whose desideratum is (3.6). If "f' is offered as a response to (3.7) so as to make (3.8) true, this satisfies the requirements of the questioner provided that (3.9) is true, and thus (3.9) is what Hintikka calls the *conclusiveness condition* of (3.4), which are the most significant notions in the theory of simple *wh*-questions. The theory of epistemic logic, which enables us to define all these important concepts for simple wh-questions, is already contained in *Knowledge and Belief,* which Hintikka only applied to questions and answers.

The problem nevertheless remains: how do we generalize these notions to other kinds of questions? To explain how Hintikka achieves this generalization, we must first ask: What are the principles of cross-identification? Clearly, they are both complicated and multifarious in real life. Hintikka rejects with counterexamples David Lewis' argument that cross-identification is based on a number of weighted similarity principles; in their jointly authored paper, "Toward a general theory of individuation

and identification,"[76] Jaakko and Merrill Hintikka argue that in typical cases, including the identification of physical objects, cross-identification depends on continuity. Additionally, the Hintikkas imply that the kind of mathematics best suited for such cross-identification tasks is the stability theory of differential equations.

This brings us to one of the most tangled and misunderstood aspects of Hintikka's philosophy, namely, his dispute with Saul Kripke over the nature of reference and rigid designation. Hintikka's distinction between principles of reference and principles of cross-identification seem to be directly opposed to Kripke's "new theory of reference." However, it is important to untangle Kripke's famous claim that trans-world identification between possible worlds is implemented by stipulative rigid designations from Hintikka and Sandu's concerns about quantification and reference. Their criticism of Kripke's theory in their 1995 paper, "The Fallacies of the New Theory of Reference,"[77] is directed primarily at Kripke's assumption that quantifiers range over a fixed set of values. The problem, in a nutshell, is that Kripke in effect misses completely the difference between (3.7), wherein x ranges over the individuals of some one possible world, and (3.6), where x "ranges over" only such individuals as can be identified in all the relevant alternatives.

It is worth taking some time to place these issues in some historical context. Over the past three decades, philosophical discussions of identification have followed the metaphysical path mapped out by Kripke in his *Naming and Necessity*. Kripke's starting-point is familiar. Any object is identical with itself and itself alone. No two objects can be identical. True identity statements are true necessarily. According to Kripke, true identity statements holding between names, for example, "Cicero is Tully" are markers of *de re* necessity. If it is true that Cicero is Tully then it is necessarily true, and this necessity stands apart from how anyone happens to come to know the true proposition.

This basic move permits Kripkeans to contend that arguments presented in *Naming and Necessity* have somehow overcome traditional Kantian objections to non-epistemic treatments of identity and have cleared the way for a revival of metaphysical inquiry free from the critical constraints of

[76] Jaakko Hintikka and Merrill B. Hintikka, "Towards a General Theory of Individuation and Identification," in Werner Leinfellner et al., editors, *Language and Ontology, Proceedings of the Sixth International Wittgenstein Symposium*, Hölder-Pichler-Tempsky, Vienna, 1980, pp. 417-22.

[77] Jaakko Hintikka and Gabriel Sandu, "The Fallacies of the New Theory of Reference," *Synthese* vol. 104 (1995), pp. 245-283. Reprinted in Jaakko Hintikka, *Paradigms for Language Theory and Other Essays*, Dordrecht: Kluwer Academic Publishers 1998, pp. 175-218.

epistemology. The necessity of identity is, after all, a straightforward theorem of modal logic and would be, according to Kripke, no matter what the state or sources of our knowledge. Such a view implies that the necessity of identity precedes any particular identification and, more significantly perhaps, that it is possible to examine the implications of some metaphysical propositions apart from all epistemological considerations. Kripke's argument is powerful and its basic premises seem incontrovertible. However, in order to understand how to build upon this metaphysical insight in order to actually conduct an investigation or application of the notion of identity or identification, one has to turn to other sources. Kripke's basic move is brilliant, but at its heart it is extremely thin.

Hintikka and Sandu understand Kripke's basic insight in *Naming and Necessity* as the claim that quantification in a modal or intensional context presupposes identity conditions that do not reduce to descriptive conditions. It is important to be clear about the target of their criticisms. They acknowledge, of course, that what they take to be Kripke's basic insight is undeniable. The theory of rigid designation that follows from the necessity of identity is criticized by Hintikka and Sandu not on metaphysical grounds, but because, by characterizing rigid designation as a relationship between names and objects, Kripke has arbitrarily restricted the sense of what it is for us to identify an individual. In fact, their criticism is intended to show that questions of reference are orthogonal to questions of identification. Once the distinction between reference and identification is established, it becomes easier to understand their criticism of Kripke's restriction on the behavior of quantifiers and the theory of rigid designation that follows from it.

To repeat the basic point already broached above: Kripke understands quantifiers as ranging over a fixed set of values. He therefore excludes the difference between identifying that, and identifying what or who, between saying for example,

'it is known that someone paid Ann,'

which has the form

$$K(x)P(x,a),$$

where x ranges over individuals of some one possible world, and

'it is known who paid Ann,'

which has the form

(x) KP(x,a).

Here the x will pick out only such individuals as can be identified in all the relevant or accessible knowledge worlds. In the second case, the individual being spoken of is identifiable in all possible worlds that are compatible with the agent's knowledge.

Once we turn to the question of understanding an agent's knowledge one must decide on whether, for example, a Kripkean account of the quantifier is appropriate. One is basically asking whether a distinction of the kind presented above, is worth retaining in one's formal apparatus. It should be obvious that this is a separate matter from the stand one takes on, for example, the metaphysical necessity of identity. One's criteria for deciding between different treatments of the quantifier will inevitably be drawn from some source other than our reflections on the *de re* necessity of identity. While Hintikka and Sandu argue that the necessity of identity is not enough to enforce the treatment of quanitifiers underlying Kripke's theory of rigid designation, Kripke may be able to defend it on other grounds.

The point here is that when we consider how one might go about quantifying-in in epistemic and other modal contexts, it is clear, even in the relatively straightforward example mentioned above, that logical connectives, quantifiers and all the rest are not sufficient for giving an account of the cross-identification for individuals.

In the case of cross-identification, what Hintikka and Sandu have suggested is that once criteria for cross-identification are specified, quantification into modal or intensional contexts becomes manageable via the specification of the relevant set of worlds and the fate of their members. This is precisely the reverse of what Kripke understood his work to have demonstrated. For Kripke, the basic insight that a thing is identical with itself and itself alone, that Nixon is Nixon, (even if he had been named something other than Nixon) is evidence that something like rigid designation is called for. While Hintikka and Sandu would certainly agree with the necessity of self-identity, they do not see this as grounds for the introduction of rigid designators. Instead, they argue that true identifications of the kind that hold any real interest for us are drawn between different ways of specifying the same thing. How one determines the appropriate critieria for such cross-identifications is not a matter for logic alone to accomplish, however, once these criteria are in place, then the ordinary quantificational infrastructure can do all the necessary work. In order to engage in any modal or intensional reasoning whatsoever, one must be able to cross-identify. Since cross-identification is conceptually prior to quantification in a modal context, it cannot be explained without moving beyond the resources of our logic *per se*.

Given its importance, Hintikka has had strikingly little to say about the non-logical principles governing cross-identification. The closest he comes is an hypothesis concerning continuity in the joint paper with Merrill Hintikka discussed above where they outline an account of how one might use the stability theory of differential equations as the mathematical framework for cross- identifications. Such a view contrasts sharply with Kripke's claim that our having stipulated the possible worlds eliminates the problem of trans-world identification. It also contrasts sharply with other attempts to understand what is involved in cross-identification. David Lewis, for example, famously suggested that we cross-identify or more accurately that we pick out counterparts across possible worlds via subjective similarity measures. Of course, Lewis was keen to point out that counterparts are never actually identical with one another. Plantinga too, in a very different way, and in a way opposed to Lewis, is also eager to point out that the denizens of possible worlds are fundamentally different (this time in kind) from those of the actual world.

While the way one understands identity may well be influenced by one's attitude towards metaphysical questions in general, the difference between Hintikka and Kripke over the existence of rigid designators as we have indicated above stems from differences concerning the nature of logic and specifically from differences concerning the nature of quantification. Logical, metaphysical and perhaps even empirical considerations of identity are thoroughly entangled. This entanglement is the site of a range of open-problems for philosophers; however, getting clear on the dispute between Kripke and Hintikka helps us to make some headway on the issue.

Individuation and identification involve us in a mess of problems. However, as we shall see, some of these problems admit of progress. For instance, one reason that there is such a problem of generalizing the treatment of simple *wh*-questions represented by the examples (3.4) – (3.9) is clarified via examination of questions involving several quantifiers. Let us ask:

(3.10) Who is each person loved by?

The desideratum of (3.10) is

(3.11) I know who each person is loved by.

The presupposition of (3.10) is

(3.12) I know that each person is loved by someone.

The logical form of (3.12) is

(3.13) $K(\forall x)(\exists y)L(y,x)$

where "L(y,x)" means that y loves x. Responses to (3.10) are of the form

(3.14) $K(\forall x)L(g(x),x)$

where g(x) is the person who loves x.

Now, let us ask: What is the logical form of (3.11)? This critical question leads us directly to the questions of quantifier dependence and independence that are the sum and substance of Hintikka's IF (independence-friendly) logic, extended in the present case to include epistemic operators as well. The connection is easily seen from looking at the form revealed by (3.11), where the truth-making choice of the lover must be a known person, the same in all my epistemic alternatives, and hence independent of K_I, that is, independent of the choice of any alternative possible world. At first glance, you might think to express this by having $(\exists y)$ precede K. But if that's what you think, then look again: $(\exists y)$ depends on $(\forall x)$, and $(\forall x)$ cannot precede K. Were $(\forall x)$ to precede K, then (3.11) would speak only on individuals known to me! Once you understand this, you can see immediately how problems can be solved by means of Hintikka's slash notation, (this will be explained in much more detail below). For of course the logical form of (3.11) is

(3.15) $K(\forall x)(\exists y/K)L(y,x)$

Likewise, and by the same token, the conclusiveness condition for (3.14) has to be

(3.16) $K(\forall x)(\exists y/K)(g(x)=y)$.

But (3.16) is equivalent both to

(3.17) $K(\exists f/K)(\forall x)(g(x)=f(x))$

and to

(3.18) $(\exists f)K(\forall x)(g(x)=f(x))$

which is analogous with (3.9). Once you see this you can see also quite readily that the form of (3.6) and (3.9) can just as easily be expressed, instead, as

(3.19) $K(\exists x/K)A(x,k)$

(3.20) $K(\exists x/K)(f=x)$

thus showing the treatment of (3.4) and (3.11) to be strictly parallel, the only difference being that while (3.19) and (3..20) have slash-free synonyms, (3.15) and (3.17)-(3.18) do not. One is almost tempted to put it like this: the difference that makes no difference in logic makes all the difference in the world. In any case, what should be obvious to all is that the generalization to all *wh*-questions is such that the general form of the desideratum of a question is expressed by

(3.21) KS

where S is a proposition that is first-order and in the negation normal form except for that some existential quantifiers are slashed ($\exists x/K$) and so some disjunctions ($\vee/K$) may be as well.

To now find the presupposition corresponding to (3.21), we omit all the slashes, such that a response to the corresponding question has a form in which we replace each subformula of S of the form

(3.22) $(\exists x/K)F[x]$

in context by

(3.23) $F[g(y_1,y_2,\ldots)]$

keeping in mind that $(\forall y_1)$, $(\forall_2)$,... are all the universal quantifiers within whose scope (3.22) occurs in (3.21), and the conclusiveness condition is but the straightforward conjunction of all statements of the form

(3.24) $K(\exists f/K)(\forall y_1)(\forall y_2)\ldots (g(y_1,y_2,\ldots) = f(y_1,y_2,\ldots))$

Our treatment here can easily be extended to propositional questions as well as to mixed ones simply by replacing some disjunctions ($S_1 \vee S_2$) in (3.21) by

(3.25) $(S_1(\vee/K)S_2)$

and then treating (3.25) as one would treat

(3.26) $(\exists x/K)((S_1 \,\&(x=0)) \vee (S_2 \,\&(x\neq 0)))$

These are just some of the results of Hintikka's logical theory of questions and answers. Not only does Hintikka's theory provide a uniform treatment of all the most general notions concerning questions and answers, it is the main tool of Hintikka's new epistemology. In combination with his second-generation epistemic logic, Hintikka's theory of questions and answers provides both analysts and synthesizers a powerful new conceptual tool that we are now free to use even more generally, as Hintikka has himself used it in collaboration with Ilpo Halonen in their application of logic to the philosophical analysis of *why*- and *how*- questions. Hintikka and Halonen show that to tell why something happens, why it is the case that S, and so on, S must be clearly derived interrogatively from whatever initial premises are available which, in scientific discourse, includes prominently some background theory. A suitably normalized interpolation sentence in the sense of Craig's interpolation theorem is a summary of the argument leading from explanatory premises to the explanandum. If a normalized interpolation sentence exists, it answers the why-question and if not, that is, when the relevant interpolation theorem does not apply, the entire unsummarized argument remains, which is an answer to a *how*-question but not to a *why*-question. Hintikka and Halonen's account of why-questions is revealing from a methodological point of view. It makes use of nontrivial logical results and evinces the relevance of Hintikka's revitalized epistemic logic to other applications.

Some of these applications are already well underway in Hintikka's own epistemological work. His logic of questions and answers allows him to formulate his interrogative model of knowledge acquisition, a novel approach to epistemology. To understand the full philosophical impact of his innovative approach, one must see his interrogative model from the standpoint of *epistemic strategies*. Hintikka understands his interrogative model as a game against nature, or against whatever (or whoever) it is that provides the answers to our epistemic inquiries. He distinguishes two different kinds of rules or principles characteristic of a game. The *definitory* rules define the game. In a game of chess, for instance, the definitory rules tell us which moves are permitted and which not, what "checkmate," "castling," etc., mean, and so on. These rules define the game of chess. If a player makes a move not allowed by the definitory rules, say by moving a pawn three spaces forward, it is not a chess move and the player must take it back. We can thus describe the definitory rules of any game or rule-governed, goal-oriented activity. However, knowing the definitory rules of a game does not mean you know how to play. You must also know what Hintikka calls the *strategic* rules (or principles) of a game. In chess, for instance, you must plan your moves, select the best course of action, make

judgments as to which moves will serve you better than others, and so on. These rules are not merely heuristic. They can be formulated as precisely as the definitory rules. This is well explained by the crucial role of *complete strategies* in von Neumann's game theory.

The results of applying Hintikka's distinction to the interrogative "games" of inquiry are striking. First, the standard rules of an interrogative game—the rules for logical inference moves as well as interrogative moves—are definitory. They tell us nothing about what to do in a logical or epistemological game. The rules for making both logical inference moves and interrogative moves merely define our game. For example, the so-called rules of inference in deductive logic are neither descriptive nor prescriptive but merely permissive, in so far as they do not tell us which particular inference or set of inferences we should draw from a given number of potential premises. The rules may tell us which inferences we are allowed to draw, for instance without our in the process of so doing committing any fallacies. But which rules? It is highly misleading even to call these rules of *inference.*

What we need, if our inquiry is going to be successful, is more than the definitory rules of inquiry. We need *strategic rules.* Indeed, the better our strategic rules, the better our inquiry. The best player in a game of inquiry is the player with the best strategy, which corresponds in game theory to what happens where values, i.e., "utilities," are associated not with moves themselves but, rather, with *combinations* of *strategies*, as in von Neuman's game theoretical notion of a *complete strategy.*

Likewise, what determines whether or not some particular inquiry is successful is not well the players follow the definitory rules but, rather, on how well the players play, namely, success depends upon a player's choice of strategy. Now, although it is highly unlikely that applying the definitory rules will by itself even further the aims of an inquiry, in so far as it fails to lead you to the desired information, but it may itself be strategically valuable. For instance, it may open up a new way of information or knowledge acquisition, say by providing presuppositions for questions that could not have been asked earlier. This also reveals something about the task of an epistemologist. You can't try to capture, say, a scientist's epistemic behavior using the definitory rules of logic. You can only do it using the strategic rules of the suitable game. Thus, when some scientific process is modeled using logic, it is not the definitory rules of that game, i.e., the rules of inference, that should correspond to what the scientist does. Rather, the strategic rules of that logic should mirror the strategic rules of a scientist's inquiry. It is for instance simply a category mistake to think that when a scientist is presented with contradictory evidence that somehow the laws of paraconsistent logic will illuminate the scientist's behavior. These logical laws are definitory, not strategic. We should likewise now be able to look at

induction in the same light: induction is a process that cannot be captured or analyzed using the inference rules of inductive logic. Induction, too, must be understood with strategies of inquiry.

In the beginning of this essay we said that to understand Hintikka we must look not to his views but at his results. These, then, are exactly the sorts of *results* of Hintikka's work that require us to make radical changes in our approach to epistemology, which the way it has traditionally been practiced of late has been severely handicapped. Even today, most analytical epistemologists are simply ignore the possibility that a revolution may be taking place in our understanding of the relationship between logic and epistemology through Hintikka's groundbreaking insights. Thus, typically, what those contemporary epistemologists who have not understood Hintikka's results do, and that is the majority of them, is to set up some sort of rule-governed processes within which the definitory rules are supposed to mimic the knowledge seeker's behavior.

Hintikka's interrogative model has other similarly strong, albeit more general, implications. Most epistemologists and philosophers of science have taken for granted the distinction between so-called "contexts of discovery" and "contexts of justification." Supposedly, rational logical and epistemological terms could only be useful in contexts of justification, not contexts of discovery. The notion of genuine rules for discovery seems an oxymoron; there cannot exist a logic of discovery, it was often repeated *ad nauseum*, only a logic of justification. Over the last several decades, there have been occasional denials both the distinction and the justification problem, but just about all actual work in epistemology has been surrounding the problem of justification. Even theories of belief change have had little affect, since therein belief change is based not on a rational agent's prospects of acquiring new information but, rather, on what the rational agent knows now. The general consensus has been that because seekers of knowledge make one move at a time, their moves cannot be understood using strategies. Such old presuppositions were built into the still generally accepted hypothetico-deductive model of the scientific knowledge seeking enterprise.

Hintikka's interrogative model changes all of this. In Hintikka's model, a context of pure discovery corresponds to a questioning game in which all the answers are known to be true. According to the received view, this is impossible to deal with from an epistemological point of view. But Hintikka shows that this is the most paradigmatic case of interrogative inquiry, which leads to another extraordinary result. First of all, in the wider sense in which logic is not restricted to deductive logic, it decisively refutes once and for all the claim that there cannot be a logic of discovery. What Hintikka has shown, to put it most simply, is this: there *can* be, because there *is*.

This case of pure interrogative discovery, the "all answers true" case, presents us with a wonderful object for study because it has even in non-leaner cases a clearly delineated structure and, in this case, the aspects of interrogative inquiry that come most into play are partly analogous to deductive reasoning. On paper, the logical step from the presupposition of a question to the conclusive answer looks like a logical inference from a premise to a conclusion. As a result, as Hintikka has shown, we can extend the metatheorems valid in first-order logic to the case of interrogative inquiry.

Hintikka's logic of interrogative discovery can easily be illustrated by asking what the optimal strategies are in the case of pure interrogative discovery. It is extremely difficult to find an absolute, general answer. Even in the limiting case of purely deductive reasoning, it is generally not possible to compute the optimal strategies. Nevertheless, Hintikka shows how nevertheless it is possible to reach an extremely fruitful *relative* answer.

Let us suppose we are in an interrogative game of pure discovery. Suppose we've come to a number of propositions. Then, the question—the crucial, most important *strategic* question—is this:

> Which of these propositions should become the presupposition for the next question?

The counterpart to this question in the purely deductive case is:

> Which of these same propositions should become a premise for the next logical inference?

There is no computational answer, that is, in neither case is there any general mechanical rule for computing the answer. However, what Hintikka shows, is this. The two questions have something incredible in common, namely, the answer to both questions is the same!

With some minor technical qualifications, we can express this astonishing result most simply by saying that in the case of pure discovery the best strategies of interrogative inquiry and the best deductive strategies in the parallel situation are, remarkably, one and the same. This reveals the real role of logic is the game of empirical inquiry. The notion that the secret of all good reasoning lies in "logic" and "deduction," what Hintikka calls "the Sherlock Holmes conception of logic," cannot be true in so far as it refers to the definitory rules of logic, that is, to the usual rules of logical inference. These rules are, necessarily, truth-preserving, which means that they cannot introduce new information to reasoning. And so although they cannot serve as vehicles of discovery, if we switch our focus from definitory rules to strategic rules, the situation is quite different. To the extent that there are

any guides, logic in the strategic sense is our guide to pure discovery. Sherlock Holmes, as Hintikka so aptly puts it, was quite right: strategically speaking, Watson, what is truly elementary is that the secret of all discovery lies in logic.

Now for some technical qualifications and explanations. There is no need for us to explain the parallelism between deductive inferences and question-answer steps mentioned above in the case of simple wh-questions, since in that case the use of a proposition of the form

(3.27) $K(\exists x)S[x]$

as a presupposition of a question yields a response in the form of a proposition

(3.28) $K\ S[b]$

where b is the individual specified by the answer. Now, the answer cannot possibly be conclusive unless

(3.29) $K(\exists x/K)(b=x)$

which allows us to substitute for b a universally quantified variable falling within "K"'s scope. This important step, from (3.27) to (3.28), which parallels existential instantiation, allows us to go from

(3.30) $(\exists x)S[x]$

to

(3.31) $S[\beta]$

where β stands for the "dummy name" or the name of "an arbitrary individual," like "John Doe" on a legal form. (3.28) and (3.31) are analogous, and the rest of the interrogative argument will preserve this analogy, which is the basis of the parallelism between deductive and questioning strategies. Now, we can extend this parallelism to more complex cases by generalizing the rule of existential instantiation. The extended form, which allows us to move from a first-order sentence $S_o = S_o[(\exists x)S_1[x]]$, is in the negation normal form. It contains the subformula

(3.32) $(\exists x)S_1[x]$

to a sentence where (3.32) is replaced by a sentence having the form

(3.33) $S_1[g(y_1, y_2,\ldots)]$

where $(\forall y_1)$, $(\forall y_2)$,... are the universal quantifiers within whose scopes (3.32) occurs in S_o. This extension restores the strategic parallelism between deduction and questioning. What we've just shown, in other words, is that we *can* speak about strategic rules of discovery. In the case of pure discovery, strategic rules of discover are closely connected with the strategic rules of deductive logic, which Hintikka shows cannot be recursive.

None of this is meant to suggest that we don't need to study interrogative games that correspond to contexts of justification. We do. In such games, some of the answers we get as a result of our inquiry can be false, which means that the true ones must be sifted out by further questioning. The complexity of such a process may seem beyond reach of our interrogative model. In point of fact, however, the complexity of the process pertains only to the strategic rules of such uncertain interrogative inquiry, not the definitory rules. All we need therefore is to make sure that the inquiry is nonmonotonic, that is, that the inquirer can reject any particular answer, what Hintikka calls "bracketing." The only difficulty is that the knowledge seeker must then also bracket all the steps that depend on the rejected one. Unbracketing, of course, is also a legitimate move.

This general case is more complicated than the pure interrogative discovery case, and here Hintikka succeeds by in effect turning the received view upside down. We can formulate the logic of discovery, and the interrogative logic of discovery is far simpler than the interrogative logic of justification. Moreover, as game theory clearly shows, it is possible to rationally evaluate not just particular moves but entire strategies. Actual scientific inquiry involves both discovery and justification.

For instance, a typical scientific paper presents the evidence leading to particular results. This same evidence is used in the paper to justify the results. The logic of justification cannot therefore be considered on its own, independently of the logic of discovery, because the ultimate goal of epistemological evaluation is to find the strategies used both in discovery and in justification. It might be a good strategy for instance to try and uncover the truth in a given situation by initial reasoning unbacked by strong justificatory evidence, simply because the very discovery of the truth can help in the quest for justificatory evidence. In science discoveries are often made on the basis of sketchy evidence and are then confirmed only with the help of that very discovery. Regardless of how shaky the initial evidence, further investigation might not have been possible without it. This may explain the false appeal of the hypothetico-deductive model. Scientific discoveries do not have to be thought of purely hypothetically; however,

they are nevertheless often reached before we have enough evidence to fully justify them.

Thus, Hintikka's new epistemology may serve to redirect the work of contemporary epistemologists. Most of that work nowadays has been with the nuances of the justification of particular beliefs in relation to the available evidence, which requires that one single step in the epistemic process be considered at a time, the one based on that particular body of evidence. Several epistemologists have considered what "warrant" one might have for some particular inference. General rules concerning such particular steps can only be definitory for some "game" of warranted inference. Hintikka, on the other hand, has shown that epistemological evaluation pertains only to strategies, not to the particular moves or to the definitory rules governing them. If he is correct, then Hintikka's epistemological results make much of the current work in epistemology moot. One point is quite clear: Hintikka's line of argument steers epistemology much closer to actual scientific practice and so, one might suggest, it serves to put the work of philosophers back on a progressive course.

Bottom line, the fact is that only up to a point do working scientists rely on a given body of evidence. A working scientist wants more evidence to answer questions that are still open, such as for instance which new experiment might help choose between competing theories, experiments that by and large can be identified only on the basis of the theory being tested and which up until that point typically is not yet backed by a lot of evidence.

Another fascinating implication of Hintikka's interrogative model of inquiry for epistemology and philosophy of science stems from the fact that in his model an interrogative game is not fully defined until one specifies what questions the respondent, be it a human being or nature, is supposed to answer. This allows us to characterize different sorts of inquiry on the basis of the nature of the available answers. The theory of quantificational complexity (or simplicity) of possible answers is one such particularly fruitful classification.

What, then, is a good scientific empiricist to do? The answer, one might think, is to stick to particular propositions under the assumption that empirical inquiry requires that all answers must be in the form of particular propositions, what we discussed in Section One under the heading of the *atomistic postulate*, the view that the world will not tell you what happens always and everywhere but only what happens here and now. Using his interrogative approach, Hintikka analyzes the implications of the atomistic postulate and shows it is indeed equivalent to assuming that the answers nature can provide to our questions are particular propositions, and as we mentioned previously, this has played an important role in epistemology and philosophy of science. Such a restriction imposed on nature's answers to our

inquiry implies that we can reach general conclusions, e.g. scientific theories, only in virtue of initial premises that are themselves already general. This means that if we assume the atomistic postulate, we must modify or complement our interrogative model in one of the following three ways:

(i) our model must include strong *a priori* assumptions
(ii) our model must be broadened with additional rules of inference introduced over and above the deductive ones
(iii) we cannot derive general conclusions from the data, not even interrogatively.

There are other possible modifications, such as Larry Laudan's suggestion that we should choose between competing theories by comparing their question-answering and problem-solving power. Hintikka's point is that each option can be seen as motivation of a major tendency in the philosophy of science. The first leads to a rationalistic construal of the scientific method. The a priori assumptions that can serve as the initial premises of inquiry might include such assumptions as the uniformity of nature. The second leads to an inductivist conception of science or to the idea of abduction providing the additional rules of scientific inference. The third option is the hypothetico-deductive model that, filtered (or perhaps we should better say *augmented*) through Hintikka's insights, should now be called the hypothetico-interrogative model.

Hintikka's interrogative model is nothing less than a multiperspectival framework for the comparative study of various apparently incommensurate approaches to scientific inquiry and the insights motivating them. Which is not to say that modifications (i)-(iii) are complete or satisfactory after all. For the consistent empiricist, strong a priori assumptions are unacceptable. Moreover, inductive and other sorts of ampliative[78] reasoning are generally not truth-preserving. Option (ii) requires further explanation as to how such rules lead to actually true conclusions. Instead of cleaning up the really crucial epistemological problems, the hypothetico-deductive model sweeps them under the rug.

Hintikka's primary insight here is that since all these different views are based on the assumption of the atomistic postulate, we should instead of adopting any of them give up the postulate. Only then can we understand the true nature of our actual scientific inquiry as working scientists practice it.

[78] Roughly speaking, the analytic/synthetic distinction can be thought of in terms of the explicative/ampliative distinction, since in an ampliative judgment (or proposition) the predicate adds something not already contained in the (meaning of) the subject-term.

Because of the nonatomic inputs into the scientific process, nature according to Hintikka can provide nonatomic answers to our questions. To find out what such answers are like, we must ask what questions scientists can ask whose answers are logically complex.

Controlled experiments, in Hintikka's view, are themselves best understood as questions put to nature. Rarely is the outcome of a successful controlled experiment a singular datum but, rather, involves the discovery of dependence. For example, we discover how an observed variable depends on the controlled one, a dependence that Hintikka has shown can, from a logical point of view, be expressed only by means of quantifiers. Answers to our experimental questions must therefore be considered as nonatomistic answers to our experimentalist's questions. This means that the motivation of (i)-(iii) disappears. Epistemologists in general and philosophers of science in particular must learn to get along without them. This is another major way in which Hintikka's interrogative approach can revolutionize both epistemology and philosophy of science.

To take the example from the history and philosophy of science discussed in Section One, consider how historians of science have grappled with the problem of how Newton could have claimed to have derived, even "deduced," his general laws from observed phenomena. Since Newton's methodology was experimentalist within the strict sense of controlled experiments, Hintikka observes, Newton's own view of his method should be surprising, once we come to understand, as Hintikka does, that Newton included among his "phenomena" outcomes of controlled experiments. Hintikka shows the sense in which Newton's statement can be seen as literally true, which is consistent with Newton's view on induction. What Newton means by *induction* is not the making of inferences from particulars to general laws but, rather, extrapolation, interpolation and other such combinations of partial generalizations. This is the same sense in which Aristotle, in Hintikka's analysis, thought we have immediate access to certain general truths by realizing within our own souls the relevant forms.

In a similar vein, Hintikka shows how we can compensate for a narrow range of available answers by formulating sufficiently strong initial premises. This, in his view, is what allowed medieval nominalists to avoid having to make inductive inferences even after they gave up the notion that the mind has direct access to the Aristotelian notion of a full-fledged realizability of forms, i.e., universals, with the addition of one sufficiently strong postulate, namely, that God placed into our minds the right innate ideas. It was only after both the metaphysics of forms and innate ideas were eliminated from the then-current canons of inquiry that the problem of induction became, as it were, a *problem*. Thus, to further extend the case in point into the modern era, the reason "Hume's problem" was not a problem as such before Hume, and the reason it became a problem in the first place,

is that Hume completely misunderstood Newton's experimentalist methodology. Not only does Hintikka's interrogative model force us to reexamine the conceptual issues in epistemology and philosophy of science, it forces us to rethink and retool the fundamental principles of the knowledge seeking enterprise then and now.

4. A TIMELY REVOLUTION: HINTIKKA'S NEW LOGIC

In his soon-to-be-published autobiography, Jaakko Hintikka tells about his dissatisfaction with most of the current trends in philosophy, especially in logic and epistemology, and about his efforts to reform large parts of the subject. One of the tools he is using in this enterprise is what has been called independence-friendly (IF) logic. Contrary to what this name might suggest, IF logic is not a new branch of logic and not a new "nonclassical" logic. (Indeed, Hintikka has himself recently suggested that a better name would be *hyperclassical logic.*[79]) It is what the traditional basic logic was supposed to be but is not, that is, a general theory of quantifiers and propositional connectives. This received logic is variously known as first-order logic, predicate logic, or quantification theory. It is only a part of the real story of logic, for it overlooks one important aspect of the role of quantifiers. This role is to express actual dependence relations between variables by means of the formal dependence relations between the quantifiers to which they are bound. Once this is realized, it is seen that we cannot represent all possible patterns of dependence and independence among variables in the received logic, which is therefore defective in an important respect.

IF logic differs from the received first-order logic in that all these patterns are representable by its means. IF logic thus marks the first substantial general improvement on basic logic since the days of Frege and Peirce and opens important new avenues for research. Among other things, it puts the

[79] In "Independence-Friendly Logic and Axiomatic Set Theory," *Annals of Pure and Applied Logic* 126 (2004) 313-333, Hintikka writes:

> The most important fact about this "new" logic is that in a deeper sense it is not new. It is not just another "non-classical logic." It was a mistake to give it a special name. Or if a nametag is absolutely necessary, the best suggestion I now can offer is *hperclassical logic.* . . . it is the so-called ordinary first-order logic that should be given a special epithet, not IF logic. (Is "dependence-handicapped" logic too abusive?) If a name is absolutely necessary, perhaps IF logic should be called "hyperclassical" in view of its retaining all the classical rules for semantical games.

concept of negation to a new light by showing that in all sufficiently rich languages there are two different negations present.

In his earlier work, Hintikka has shown how IF logic makes possible truth definitions that were earlier thought of as being impossible. Currently, Hintikka is engaged in showing how IF logic with its different ramifications forces us to reconsider the entire foundations of mathematics. He is in the process of showing how all mathematical reasoning can be carried out on the first-order level, that is, without quantifying over any higher-order entities. Among other novelties, Hintikka is engaged in showing how the consistency of elementary arithmetic based on IF logic can be proved by elementary means. This is a partial realization of the grand project of Hilbert's which has mistakenly been thought of as being discredited by Gödel's results. It is also a positive solution of the second one of Hilbert's famous list of open problems in mathematics.

It is of course well known that Kant's philosophical revolution did not include logic. Aristotle's logic according to Kant was as it were a view, if one could even speak of it as such, with no room, that is, no room for improvement. Since then, in case anyone has been asleep for the past century and a half, Aristotelian logic has gone the way of classical physics. Yet, just as there some physicists and unfortunately many philosophers with a shall we say Newtonian attitude toward relativity and quantum mechanics, there is something of an Aristotelian attitude pervasive throughout the knowledge seeking enterprise, mutated into the notion that Frege and Russell have the last definitive word on what generally is called first-order logic, quantification theory or predicate calculus, and generally recognized as the core area of logic, what sometimes is called "elementary logic."

What are the preconditions of the applicability of a first-order language? They of course include prominently the specification of a domain of individuals (e.g. "universe of discourse") over which all the individual variables range and a contextual elimination of all other singular noun phrases (e.g. Russell's "denoting terms").

What makes such a language first-order? Logically speaking, quite simply, the values of the variables are always individuals. When a first-order theory is thus devised for other kinds of entities such as *sets*, they must therefore themselves be reified into individuals. Thus the leading role played by quantifiers among the symbols of first-order logic is, from a semantical point of view, typically explained in terms of their "ranging over" the entire domain of individuals. The reason for this leading role is that dependencies between different variables can only be expressed in a first-order language by the dependence of the quantifiers on each other to which the variables are bound. When we consider, for instance, the sentences

(4.1) Someone loves everyone,

and

(4.2) Everyone is loved by someone,

we can easily see that in the latter the truth-making value (if any) of the variable *someone* depends on the value of the variable *everyone*, while the truth of the claim about the variable *someone* depends importantly on the value of the variable *everyone*. Whereas in the latter the truth-making value of the variable *someone* depends not on the value of the variable *everyone* but, rather, the truth of this claim about the variable *everyone* depends importantly on the value of the variable *someone*. This is most easily seen by showing the respective forms of (4.1) and (4.2), as follows:

(4.3) $(\exists x)((\forall y)(x \text{ loves } y))$

(4.4) $(\forall y)((\exists x)(x \text{ loves } y))$

Notice that in (4.3), $(\exists x)$ does not depend on $(\forall y)$, whereas in (4.4) it most clearly does. Now, the quantifiers that are dependent on a given one, say $(\forall z)$ are the ones that lie in its scope, indicated by a pair of parentheses following the quantifier in question, like so:

(4.5) $(\forall z)$ (———)

scope

All this is well enough familiar to anyone who has but glimpsed any logic textbook and, in any case, until Hintikka's breakthrough was of interest only to logicians. Hintikka has however discovered a remarkable link between these concepts and the ways in which logical concepts serve the purpose of representing reality, for instance when logical and mathematical concepts are used in science. Hintikka asks: What must a language be able to express to be adequate for the representation of reality? Of all the many answers, the most relevant if not the most obvious is that a language must at the very least be able to represent any possible pattern of dependence and independence between variables. This is in fact the launching point of some of Hintikka's most profound work in logic. In traditional first-order logic, the dependence of a variable on another is expressed by the dependence of the quantifier to which it is bound on the quantifier to which the other one is bound. That is, the dependence and independence of variables is expressed by the dependence and independence of quantifiers. Thus in a sentence having the form

(4.6) $(\forall x)(\exists y)\, S[x,y]$

the truth-making value of the y (regardless of whether such an individual exists) depends on the value of x, a relationship expressed by the dependence of the existential quantifier ($\exists y$) on the universal quantifier ($\forall x$). Quantifier dependence is expressed in the received quantification theory by the nesting of the syntactical scopes of the different quantifiers. A quantifier ($\exists y$) depends on ($\forall x$) in a formula S if and only if it occurs in the scope of ($\forall x$).

For simplicity sake, let us take S as being in a negation normal form. We can then see the major flaw in the received Frege-Russell logic: all possible patterns of dependence and independence between quantifiers cannot be expressed in it because not all such patterns can be captured by the nesting of scopes, which transitive and asymmetrical and hence incapable of codifying intransitive or symmetrical dependence relations between quantifiers. Many patterns of dependence and independence among variables are therefore inexpressible in a language whose logic is the ordinary first-order logic.

This flaw is built into the formation rules of our received quantification theory. Hintikka has thus taken it upon himself to extend our usual first-order logic so as to remove this flaw. In "No Scope for Scope?"[80] Hintikka shows how such an extension can be carried out most simply by as it were *liberalizing* the way in which we use the parentheses to define the scopes of different quantifiers.

Parentheses serve two entirely different purposes in first-order languages, expressing respectively what Hintikka calls *priority scope* and *binding scope*. On the one hand these parentheses express through their nesting relations the relative priorities of the different quantifiers. On the other hand, they mark the segment of the formula in question where a variable is bound to the given quantifier. Hintikka is perhaps the first logician in history to realize that because there is no reason why these two should always go together in the semantics of natural language these two functions of scope have to be distinguished from each other. In an elegant way, he has shown that this simple distinction solves in one fell swoop the problem of so-called donkey sentences that has occupied theoretical linguists. Consider, for instance, the notorious donkey sentence, "If Peter owns a donkey, he beats it," whose intended logical form is

$(\forall x)((D(x) \,\&\, O(x) \supset B(x))$.

[80] "No Scope for Scope?" *Linguistics and Philosophy* vol. 20 (1997), pp. 515-544.

The problem is how the existential quantifier that is the indefinite article in the donkey sentence can be transformed into the universal quantifier, as above. Hintikka shows that

> All problems concerning such simple donkey sentences in fact disappear in one fell swoop as soon as we acknowledge the difference between binding scope and priority scope. All that needs to be done is to assume that the priority scope of *a donkey* comprises only the antecedent of [the donkey sentence above] while its binding scope comprises also the consequent as is spelled out in [the donkey sentence expressed in the logical notation, as obove]. This is eminently natural. ("No Scope for Scope?" p. 26.)

But in formal logic as well, simply by separating these two functions of parentheses and by liberalizing the requirements on the binding scope, we can build a much stronger first-order logic than the received one. As it turns out, however, such liberated use of parentheses is apt to be highly confusing. Hintikka therefore coined a new item of notation, the slash, "/", which serves to express the independence of a quantifier from another one in whose (syntactical) scope it occurs. Thus in a sentence of the form

(4.7) $(\forall x)(\forall y)(\exists z)(\exists u)\ S[x,y,z,u]$

the truth-making choice of z depends on both $(\forall x)$ and $(\forall y)$, and likewise for u, what is sometimes referred to as choices of *witness individuals* that vouchsafe the truth of a sentence in question. In contrast to (4.7), in the sentence

(4.8) $(\forall x)(\forall y)(\exists z/\forall y)(\exists u/\forall x)\ S[x,y,z,u]$

the choice of a truth-making value of z depends only on $(\forall x)$ and the choice of a truth-making value of u depends only on $(\forall y)$. It can easily be seen that (4.8) cannot be expressed in ordinary first-order logic by showing that such a pattern of dependence relations cannot be captured by any linear ordering of the four quantifiers. Since $(\exists z)$ is independent of $(\forall y)$ but dependent on $(\forall x)$, in ordinary first order logic it must be placed after $(\forall x)$ but before $(\forall y)$, and vice-versa for $(\exists u)$. But then there is no adequate linear ordering of the four quantifiers $(\forall x)$, $(\forall y)$, $(\exists z)$ and $(\exists u)$. Thus (4.8) cannot be expressed in ordinary first-order logic without Hintikka's slash notation (or some such device). Consider the sentence