DIOGENES

Diogenes 224: 101–121
ISSN 0392-1921

The Philosophy of Jaakko Hintikka, *The Library of Living Philosophers*, Volume XXX, Edited by Randall E. Auxier and Lewis Edwin Hahn, La Salle, Open Court 2006, 971 pp., ISBN-13: 978–0-8126–9463–5

1. Introduction

For more than fifty years, Professor Jaakko Hintikka has reshaped the philosophical scene through his contributions to logic, epistemology, philosophy of science, philosophy of language, and the history of philosophy. His numerous books and articles solve difficult problems, ask new questions and set forth new methods that have opened up new avenues for research. Hintikka has been a pioneer in many areas. The vastness of the field he has investigated in logic and philosophy has been considerable. To shed light on all the facets of this protean work, the editor of this volume called upon twenty-seven renowned experts who themselves have contributed in a significant way to research in these areas.

Hintikka has invented new methods to solve unresolved problems. It is not surprising that there has not always been unanimous agreement regarding his methods and his solutions. One fascinating feature of this book is the intensity of the debate that takes place between the contributors and Hintikka. The debate is always constructive and often affords Hintikka an opportunity to clarify the manner in which he has formulated his theses, to improve his arguments or to advance new arguments.

The work, which opens with a brilliant preface by the editor, is divided into three parts. The first part is an intellectual autobiography, the second a series of descriptive and critical essays on Hintikka's philosophy with his replies to them. The third part is an exhaustive bibliography of his writings. The book includes a very detailed index.

The second part includes twenty-seven contributions falling under four headings: I. History of Philosophy; II. Logic and Language; III. Truth and Consequences; IV. Epistemology and Philosophy of Science.

Ten essays fall under the first of these headings.

1. 'Hintikka's Views on the History of Philosophy' by Simo Knuuttila;
2. 'Hintikka's Ideas about the History of Ideas' by Gabriel Motzkin;
3. 'On the Use and Abuse of Logic in Philosophy: Kant, Frege and Hintikka on the Verb 'To Be' by Juliet Floyd;
4. 'Hintikka on Aristotelean Constructions, Intuitions Kantian and Peircean Theorems' by Judson C. Webb;
5. 'Hintikka, Aristotle and Existence' by R. M. Dancy;

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DOI: 10.1177/0392192110365274

https://doi.org/10.1177/0392192110365274 Published online by Cambridge University Press

6. 'The Method of the Analyst' by Aaron Garret;
7. 'Speculative-Hermeneutic Remarks on Hintikka's Performatory Interpretation of Descartes' *Cogito, Ergo Sum*' by Karl-Otto Apel;
8. 'Hintikka on Phenomenology' by Dagfinn Føllesdal;
9. 'Private Language' by David Pears;
10. 'Phenomenological Language, Thoughts and Operations in the *Tractatus*' by Mathieu Marion.

It is impossible to do justice in equal measure to the twenty-seven contributions within the framework of this review. Obliged to make choices, I have opted to focus on the essays on logic and epistemology and to comment but briefly on the historical section. This choice is dictated by obvious practical considerations and does not reflect any value judgment on my part.

To provide readers not already familiar with Hintikka's work with the necessary background knowledge, I shall occasionally drop brief reminders with the help of the Autobiography and I shall at times depart from the order in which the essays appear in the book.

2. The history of philosophy

The twentieth century underwent renewal in the way history of philosophy was conceived. Hintikka was one of artisans of this renewal. It is therefore not without reason that the essays devoted to this discipline make up a third of this book. The first two papers are specifically devoted his methodological innovations in this area. The first, entitled 'Hintikka's View of the History of Philosophy' is by Simo Knuuttila. The second, entitled 'Hintikka's Ideas about the History of Ideas' is by Gabriel Motzkin.

Scholars who do not allow themselves to use the concepts of contemporary philosophy in studying philosophical works of the past out of fear of sounding anachronistic deprive themselves of an invaluable tool. On the other hand, those who adopt an ahistorical stance toward the past and favor the systematic approach risk seriously distorting the object of their study. The *hermeneutic* school, of which Hans Georg Gadamer is one of the emblematic figures, specifically seeks to circumvent both these hazards. For Gadamer, the historical approach and the systematic approach are inseparable. They are connected dialectically. There are not two levels of interpretation, but two phases of the same process of interpretation and understanding.

Despite certain similarities, Hintikka's approach differs appreciably from Gadamer's. As Knuuttila writes, Hintikka is much more interested in the different ways in which concepts are used and arguments developed than Gadamer and his disciples have been.

To Gabriel Motzkin, who attributes to Hintikka greater interest in comparative philosophy than in the study of the past as such, Hintikka replies that the vitality of the different types of historical research depends upon the cooperation of that historical research with systematic research, including with the contemporary (philosophical and scientific) developments.

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In reading Hintikka's work, one realizes that recourse to recent logical or philosophical theories is sometimes indispensable for understanding the theories of the past. Take, for example, Leibniz' theory of windowless monads and the metaphysical principle of pre-established harmony. Why does the theory of windowless monads require this principle? Because, Hintikka answers, monads can only be windowless if the relations of mutual dependence are synchronized in such a way that *a*'s dependence on *b* is always the inverse of *b*'s dependence on *a*. However, the formulation of this type of complex relation is only possible with the help of *independence friendly logic*, a logic that will be discussed at length later on.

Another striking example of the way in which a contemporary philosophical advance can shed light retrospectively on a theory of the past is the interpretation of the *Cogito* proposed by Hintikka in '*Cogito, Ergo Sum*, Inference or Performance?' The originality and the pertinence of his interpretation is brought out by two contributors: Aaron Garrett in 'The Method of the Analyst' and Karl-Otto Apel in 'Speculative-Hermeneutic Remarks on Hintikka's Performatory Interpretation of Descartes' *Cogito, Ergo Sum*'.

Descartes did not come to know his own existence by passively contemplating a chain of deductive reasoning, as the word '*ergo*' might suggest. Actually performing the Cartesian procedure involves something more: the exercise of the will. The *Cogito* is, as Aaron Garrett writes, the freest of all acts.

Hintikka takes advantage of Garrett's study to underscore the difference between the syllogisms practiced by Aristotle and the Cartesian *Cogito*. The former are necessary, Hintikka writes, not only because the conclusion follows necessarily from the premises, but also because whoever understands the premises in his mind must act in accordance with them. In contrast to Aristotelian necessitarism, the *Cogito* is the result of a deliberate, voluntary thought-act on the part of the subject. It cannot have the timeless necessity of an inference in the Aristotelian sense, because its certainty is restricted to the moment at which the act is performed.

Descartes discovered the subject and inaugurated a novel paradigm in philosophy, the *philosophy of consciousness*. But the *Cogito* is not a fact of consciousness obtained through introspection. To grasp the significance of this, Apel observes, Descartes had to transcend the paradigm he had just inaugurated.

We better understand the power of the *Cogito* today. Indeed twentieth century philosophy witnessed the emergence of a new philosophical criteriology which makes the *public* act of arguing, mediated by language, the court of last appeal for evaluating the validity of a thesis. Even subjects who attempt to persuade themselves in their heart of hearts that they do not exist claim that their thought has *intersubjective validity* and are drawn into a type of self-contradiction that Apel calls 'performative'.

One of Hintikka's most remarkable contributions to the history of philosophy lies in his establishment of kinship among several theories throughout the centuries. Judson Webb pinpoints one of these areas of kinship in his paper entitled 'Hintikka on Aristotelean Constructions, Kantian Intuitions and Peircean theorems'.

Hintikka credits Webb with having brought to light in a more in-depth way than he himself had the connections existing between the *ekthesis* of Aristotelian logic, the concept of same name in Euclid, the Kantian idea of intuition in mathematical

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proofs, the Peircean conception of iconicity of reasoning and the notion of instantiation as it appears in contemporary logic.

Aristotelian syllogisms are purely analytical. The conclusion is derivable from the premises without the intervention of auxiliary constructions. Does analytical reasoning of this kind suffice to account for mathematical reasoning? A whole series of philosophers have tackled this question. Here again, Hintikka has reconstituted the history of their responses and then offered an original solution that sheds light on the contributions made by his predecessors.

At the conclusion of a very detailed analysis of Kant's successive positions on the role and nature of intuition in geometrical proofs, Hintikka has concluded, as Webb reminds, that Kant realized that certain lines of reasoning require recourse to auxiliary constructions.

Kant anticipated Peirce's famous distinction between *corollarial* and *theorematic reasoning*. In the case of reasoning of the first kind, it suffices to imagine any case in which the premises are true in order to perceive immediately that the conclusion is true in that case. To carry out the second kind of reasoning, it is necessary, in addition, to experiment in the imagination on the image of the premises in order for the result of such experiences to make corollarial deductions that lead to the truth of the conclusion.

Hintikka was not content with just noting this kinship between Kant and Peirce. He reconstructs the corollarial-theorematic distinction using the conceptual tools of the logic of quantification. For him, 'a valid deductive step is theorematic if it increases the number of layers of quantifiers in the proposition in question'.

Hintikka has profound affinities with Kant. As Juliet Floyd shows well in her paper entitled 'On the Use and Abuse of Logic in Philosophy: Kant, Frege, and Hintikka on the Verb '*To Be*', Hintikka adopts a philosophical stance akin to Kant's transcendental stance in so far as, like Kant, Hintikka concentrates on what humans can do to reach knowledge and the conceptual means they need to achieve that.

As Hintikka acknowledges in his reply to Floyd, his transcendental stance is concretely manifested in his work when he reconstructs *language games* in his way. It is most especially evident in the 'games' of *seeking* and *finding* which are basic modes of human behavior.

Hintikka has written extensively on Wittgenstein, to whom he devoted a book written with Merrill B. Hintikka. Two papers are devoted to this part of his historico-exegetical work: 'Private Language' by David Pears and 'Phenomenological Language, Thought and Operations in the *Tractatus*' by Mathieu Marion.

From what premises can one deduce the Wittgensteinian thesis of the impossibility of a private language? During the years following the publication of the *Philosophical Investigations*, philosophers generally responded by citing the verification principle. Pears rejects this answer arguing that Wittgenstein never subscribed to the verification principle. He proposes a weaker premise: Speaking a language is something that we do *intentionally* with knowledge of what counts as *succeeding* in doing it.

Taking a fresh look at the problem of private language, Hintikka argues that if we can talk about our private experiences in their qualitative sense, it is by virtue of the consilience of our experiences and the associated behavior and, more basically, cour-

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tesy of certain *regularities* that fortunately exist, but which are in no way guaranteed by any conceptual necessity.

Hintikka's and Marion's interpretations of the *Tractatus* agree in certain respects and diverge in others. One of the points of disagreement is over whether there is room for *intensions* (with an 's') in the *Tractatus*.

Marion responds affirmatively to this question. He sets forth two arguments. First, propositions are defined in the *Tractatus* (2.201) as depicting by representing a *possibility* of existence or non-existence of a state of affairs. Second, unlike Frege, who defined truth functions as having truth-values (True and False) as their arguments and values, Wittgenstein defined them as the result of operations having elementary propositions as bases (*Tractatus* 5.234). Here is the full aphorism: 'The truth-functions of elementary proposition, are results of operations which have elementary propositions as bases (I call these operations truth-operations)'.

Hintikka objects that what is *intensional* must somehow involve *human thinking*, which is not the case of propositions defined in terms of possible states of affairs.

Some philosophers, among them Dagfinn Føllesdal, Claire Ortiz Hill and Guillermo Rosado Haddock, are striving to bridge the gap separating analytical philosophy and phenomenology. Hintikka has also taken an interest in this project.

Of all the reductions introduced by Husserl into philosophy, Hintikka examines just one, namely, the *transcendental reduction,* the method by which philosophers bracket out the objects of the world and concentrate on the *noemata*. Hintikka criticizes this approach for bracketing not merely objects, but also the relation binding the *noemata* to objects. 'You simply cannot', he writes, 'be aware of a relation's holding between two terms if you are not aware of both of the two terms.' In applying the transcendental reduction, one loses the *noemata's* relationship to the objects along the way.

Føllesdal's paper, entitled 'Hintikka on Phenomenology' seeks to reply to Hintikka's objections and to shed light on some Husserlian theses of major importance. Concerning the transcendental reduction, Føllesdal argues that only the *noemata* are left after it has been applied. Entities other than the *noemata* survive transcendental reduction, namely, the *noeses* and the *hylé*.

Moreover, the *noemata* are not ideas interposed between the ego and objects. They are, Føllesdal writes, *transcendent* and enable us to anticipate many features of the physical object, sometimes unconsciously. The anticipations are *a priori*, but subject to rectification.

Hintikka willingly acknowledges that consciousness and its objects are 'interwoven', but continues to find the explanation of the relationship of *noemata* to their objects proposed by Føllesdal inadequate.

It was undoubtedly in 'Semantics: A Revolt against Frege' that Hintikka formulated most forcefully his rejection of the distinction between four senses of the word 'is', that of identity, of existence, of predication and of inclusion. It happens that no distinction between the meanings of the verb 'to be' can exist in the game semantics that he has invented.

In his paper entitled 'Hintikka, Aristotle and Existence', R. M. Dancy endeavors to take up the challenge of eliminating the diversity of meanings of the verb 'to be' without appealing to game semantics. At the conclusion of an in-depth analysis

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of the dichotomies *identity versus predication* and *existence versus predication*, he suggests interpreting Aristotle's famous proposition that Being 'is said in many ways' (*Metaphysics* Z, 1028) as alluding to different *uses* rather than different *meanings* of the verb.

3. Epistemic logic

Hintikka's[1] first published work, *Distributive Normal Forms in the Calculus of Predicates*, contains a new method of proof that represented a major discovery. This method was contemporaneous with Beth's method of semantic tableaux. The book that made Hintikka famous, *Knowledge and Belief: an Introduction to the Logic of the Two Notions*, appeared in 1962. Since that time, Hintikka has been considered the founder of modern epistemic logic.

Three essays of *The Philosophy of Jaakko Hintikka* are devoted to epistemic logic. They are by Johan van Benthem, Risto Hilpinen and Matti Sintonen. Since these essays discuss Hintikka's second generation epistemic logic and appeal to concepts invented by Hintikka well after the publication of the book that founded the field, we shall only discuss those essays after having introduced those concepts.

4. Game semantics

The invention of game semantics for quantifiers was straight away perceived as being an important innovation. A question immediately comes to mind. What is the relation between Hintikka's concept of *game* and Wittgenstein's notion of *language games*? In his intellectual autobiography, Hintikka acknowledges that the Wittgensteinian idea of language games inspired him, but only up to a certain point.

Wittgenstein maintained that the concept of language game was a notion without hard-and-fast boundaries and a sharp definition. In contrast, Hintikka formally specifies what the language games he deals with consist in, especially the games underlying the interpretation of quantifiers and the interpretation of the notion of truth.

As Hilpinen has shown, Charles S. Peirce glimpsed the possibility of creating a game semantics for quantifiers, but unlike Hintikka, he never made systematic use of this idea in developing his theory of logic. Hintikka suggests that what Peirce lacked was the idea of *strategy*.

In this regard, Hintikka has drawn a conceptual distinction that has proved fruitful in many areas, the distinction between *definitory rules* and *strategic rules* that he explains in his Autobiography using the following example. If you break the definitory rules of the game of chess, you are simply no longer playing chess. The definitory rules define the game.

But to be a good player, you need more. You have to have an idea of what is a good or bad move in a chess game. To possess this type of skill is to have a strategy. We shall see below that the notion of strategy can shed light on the semantics of anaphoric pronouns in natural language.

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Any semantics must explain the property of language that Wittgenstein described in these terms in the *Tractatus* (4.03): 'A proposition must communicate a new sense with old words'. To satisfy this requirement, many semanticists adopt the principle of compositionality which may be stated as follows: the meaning of the whole depends on the meaning of the parts and the manner in which they are combined.

In a semantics constructed in accordance with this principle, the meaning of the whole is constructed *recursively* from the meaning of the parts. Such a semantics works *from the inside out*. This method was first applied to formal languages by Tarski. It was then applied to fragments of natural language by Montague.

Hintikka's game semantics is diametrically opposed to the principle of compositionality. Hintikka stresses this point in a passage in which he compares Tarski's semantics and his own semantics based on the notion of game. In game semantics, one starts with a complex statement and at each stage one replaces the complex statement by a simpler statement that will in turn serve as *input* for the following move. In other words, game semantics works *from the outside in*.

One of the reasons that led Hintikka to replace compositional, recursive semantics by game semantics is the existence of a class of sentences for which interpretations that proceed from the inside out do not provide the interpreted sentence with the expected meaning.

Wilfrid Hodges cites a sentence of this kind in his paper. Consider the sentence: 'A man I met on a train sold me his hat'. The possessive pronoun 'his' obviously refers to the man met in the train. Compositional semantics handles that without any problem. But, let us put the sentence 'I collect memorabilia of Elvis Presley' before the sentence we have just read so as to obtain the following sentences: 'I collect memorabilia of Elvis Presley. A man I met on a train sold me his hat.' Here it is clear that the possessive pronoun 'his' no longer refers to the man met on a train, but to Elvis Presley. To arrive at the proper interpretation, one has to take a sequence of sentences, rather than one sentence, as a semantic unit and proceed from the outside in. It was cases of this kind that inspired Hintikka to think that the assigning of an antecedent to an anaphoric pronoun is determined by a strategic choice.

In her preface to the collection of articles by Hintikka entitled *Fondements d'une théorie du langage*, Nadine Lavand stresses that Hintikka is no longer looking for the source of creativity of language in recursion, but conceives of language as an activity oriented towards a goal, which enables him to conceive of its creativity as much more powerful and more subtle than a simple combinatory effect (Hintikka 1994).

We have before us two semantics, one of which runs counter to the other. Need we choose between the two? Are they mutually self-exclusive? Higginbotham's paper helps answer this question.

5. The scope hypothesis (James Higginbotham)

In his paper, James Higginbotham studies context-free grammars with a suitably parallel semantics. The structures generated by these grammars are trees. For example, if a grammar rule G puts together trees $T_1, \ldots T_n$ to form a new tree T_0 whose root dominates every point in the tree T_i, $1 \leq i \leq n$, then, assuming that the semantics is

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parallel to the syntax, the interpretation of τ_0 is determined by that of τ_i, but when τ_0 combines with other elements to form a superordinate tree, the semantics may not look any longer at the τ_i. One sees, therefore, that in a grammar of this type and the corresponding semantics, the compositionality is local.

Higginbotham then discusses the ways in which linguists define the notion of *scope* in their formalizations and raises the question of their compatibility with the branching quantifiers that Hintikka uses in some of his work. Without going into detail, Higginbotham's response to this question may be summarized by saying that linguistic formalizations may accept branching quantifiers provided that the constraints imposed upon the construction of trees are relaxed.

The outcome of all that is that the problem of compositionality is much more complex than it seems at first sight and that even if linearity is abandoned, a weak form of compositionality must be retained.

In his reply to Higginbotham, Hintikka questions the explanatory value of the concept of scope and sees the scope relations of natural language as derivative relations created by more basic semantic regularities.

6. Transworld identification of individuals

In the previous section we saw that Hintikka is opposed to the principle of compositionality. We are now going to see that he is just as adamantly opposed to another semantic theory that has many proponents: Kripke's theory of rigid designation.

The identification of individuals across time is in principle not a problem. We possess criteria for that. Identifying them across possible worlds is much more problematical. In 1972, Kripke proposed a new approach to the problem. 'I have a table in my hands', he wrote, 'I can point to it, and when I ask whether *it* might have been in another room, I am by definition talking about *it*.'

For Kripke transworld identity is procured by *dubbing*. Possible worlds themselves are not *discovered*, but *dubbed*. The identity of the table of the real world with a table in a possible world is determined by the very dubbing that introduces this possible world. That being so, Kripke considers himself authorized to form a particular class of individual constants that pick out the same individual in all possible worlds: *rigid designators*.

As long as the possible worlds under consideration are worlds created by dubbing, Kripke's theory seems tenable. It is no longer applicable, however, when by 'possible worlds' we mean possibilities like that of having to contend with a hurricane during a trip we are planning to make to the Tropics. The possible worlds envisaged here are not worlds of our fabrication, but worlds compatible with what we know or believe.

When it is a matter of the second kind of possible worlds, rigid designators no longer suffice. The question that then arises is: 'What are the transcendental preconditions for successful identification?'

Hintikka had already found an answer to this question with Kantian overtones in the sixties. We can *trans-identify* individuals, he affirmed, if we master the individuating functions that deliver the very same individual in all relevant possible worlds.

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Our mastery of such functions is formally expressed in formulas of quantified modal logic such as (1) $\exists xN(b = x)$, (2) $\exists xK_i(b = x)$ or (3) $\exists xB_i(b = x)$, called 'modal profiles'. The first is suitable for conceptually possible worlds, the second for epistemically possible worlds, that is compatible with what the agent knows, and the third for doxastically possible worlds, that is compatible with what the agent believes.

7. Hintikka and the errors of the new theory of reference (Gabriel Sandu)

In an article published in 1995, Hintikka and Gabriel Sandu attacked Kripke's theory of rigid designation and argued that it is both fallacious and useless. Modal profiles would suffice in every case. In his contribution to this volume, Sandu nuances the statements he made in 1995. As for Hintikka, he maintains his stand.

Sandu presently advocates the coexistence of rigid designators and modal profiles. According to him, both are necessary. Rigid designators designate the same individual everywhere, while modal profiles designate the same individual *relative to a particular context*. For example, the modal profile expressed by $\exists xN(b = x)$ allows b to designate the same individual across conceptually possible worlds. On the other hand, it fails to trace the same individual in the array of worlds compatible with what the agent knows or believes.

In his reply to Sandu, Hintikka states that we have no need of terms that behave rigidly in *all* contexts.

What is brand new in Hintikka's reply to Sandu is the argument advanced to reject universal rigid designators. Hintikka points out that there is no relationship of implication between profiles (1), on the one hand, and (2) or (3), on the other hand. Indeed, there are worlds compatible with the agent's knowledge or beliefs that are not conceptually possible worlds. That happens when agents do not know the reference of certain terms of their language. One cannot subsume, he concludes, one of these contexts under the other, and even less can one include all the particular contexts in a general context.

8. Independence friendly logic

Game semantics initially dealt with acts of interpretation of two players who at each point knew the earlier moves. In game theory terminology, game semantics were *games with perfect information*. Hintikka quickly realized that he could generalize his approach if he broke with this constraint of perfect information. That led him to imagine game semantics in which the players' acts of interpretation are independent from one another.

To represent this independence in language, Hintikka developed a new logic that had several properties in common with first-order logic, but was more expressive. He gave it the name 'independence friendly logic' (IF logic). Daniel Kolak has given a succinct presentation of this logic from which we borrow this summation:

In standard first-order logic, the relation of dependence between quantifiers is represented by the *nesting of their scopes*. For example, in the statement $(\forall x)((\exists y)(x$

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loves y)), the universal quantifier has priority over the existential quantifier that follows it and falls within its scope. Since the relations captured by the mechanism of scope are transitive and asymmetrical, first-order logic is incapable of codifying the intransitive or symmetrical relations between quantifiers.

To remedy this shortcoming, Hintikka initially appealed to Henkin's branching quantifiers. Later, he introduced the slash into his symbolism. This slash is used to express the independence of a quantifier (of a connective, of a modal operator) with regard to another quantifier within the syntactical scope in which it falls.

IF logic succeeds in capturing differences of meaning that are easily expressible in vernacular language, but which are obliterated by first-order logic. There is a price to pay for this increase in expressivity: certain good properties of first-order logic are lost. This is the case for completeness, but many other good properties are preserved.

The standard formalization of the statement 'Some relative of each villager and some friends of every city dweller hate each another' is $(\forall x)(\forall y)(\exists z)(\exists u)S[x, y, z, u]$. The values of the bound variables z and u depend both on the values of the bound variables x and on the values of the bound variables y. It is consequently not possible to express that the value of 'some relatives' depends solely on the value of 'each villager' and that the value of 'some friends' depends only on the value of 'each city dweller'. However, these relations of selective dependency are easily expressed if we use the slash. In IF logic, the statement is formalized in this way: $(\forall x)(\forall y)(\exists z/\forall y)(\exists u/\forall x)S[x, y, z, u]$.

9. Epistemic logic and game theory (Johan van Benthem)

In his paper, Johan van Benthem acknowledges, along with Hintikka, that linear operator order imposes undesirable dependencies upon first-order logic. 'There are many reasons', he writes, 'for breaking away from this – in logic, philosophy, linguistics, computer science or even physics'.

Hintikka has used generalized game semantics to interpret IF logic and, in particular, second generation epistemic logic. Van Benthem does the opposite. He shows that by appealing to new formalizations, one can describe and extend game semantics in new directions.

Van Benthem begins by developing a general method for formulating the instructions of an algorithm which allows the logician to construct game trees for the formulas of IF logic in the spirit of Hintikka's proof trees. This objective is reached by the systematic, detailed examination of cases of kind.

Van Benthem then shows how one of the new formalizations mentioned above, namely dynamic-epistemic logic, can be used to reason about actions of players and their changing states of knowledge or ignorance. He formulates the axioms of a minimal logic that is correct and complete for the models in question. Owing to this approach, it becomes possible to deal with several sorts of imperfect information of which people have been unaware up until now.

When new operators like the *common knowledge* operator were introduced, epistemic logic became much more powerful. Van Benthem recommends an analogous

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extension of IF logic that would enable it to formalize coordinated actions by groups of agents (coalitions). The extension of IF logic that he envisages would lead us to treat the players V and F no longer as individuals, but as teams.

At the end of his paper, van Benthem brings up some different ways of constructing a logic that would contain both dependent quantifiers and independent quantifiers. This logic may be considered as an alternative to IF logic. Contrary to what one might expect, this alternative logic is no more complex than first-order logic. Moreover, it is decidable.

10. Jaakko Hintikka on epistemic logic and epistemology (Risto Hilpinen)

Questions can be analyzed as requests for information. The inquirer desires to know something. It is therefore not surprising that in formalizing the questions, one calls upon epistemic operators. The question 'Is the light red or yellow?' expresses the request 'Bring it about that I know that the light is red or I know that the light is yellow' asked by inquirer n to the respondent i. To formalize the request 'bring it about', a new symbol is introduced, namely ID_n where D_n may be read 'n brings it about that' (the analogue of Belnap's *stit* operator). I expresses the imperative mode. The question is finally formalized: $ID_n(K_ip \vee K_iq)$.

This question is a propositional question. There are other sorts of questions, like, for example, 'Who is the president?', which can be rendered: 'Bring it about that I know who is the president'. Here the *desideratum* is $(\exists x)K_i(x$ = the president), where the existential quantifier trans-identifies an individual across the epistemic possibilities of the inquirer (descriptive trans-identification).

Hilpinen then invites us to imagine an agent Bingo who is watching a horse race. He is there for the first time and only knows the horses by the number that their jockey is wearing on his back hooked on to his jersey. To formalize the question 'who is No. 4?', we have to have a *sui generis* method of trans-identification (perspectival trans-identification) and a new kind of existential quantifier: $(\exists x)K_b(x$ = no.4).

In his reply, Hintikka defends the thesis that the logic of 'perspectival' identification accounts for the *indexical reference* that plays such a major role in Kripke's theory of rigid designation. It would even free us from having to resort to the latter.

11. Is independence friendly logic a first-order logic?

This important question is discussed in three papers, that of Solomon Feferman entitled 'What Kind of Logic is 'Independence Friendly' Logic?', that of Wilfrid Hodges entitled 'The Logic of Quantifiers' and that of Jan Wolenski entitled 'Tarskian Truth and post-Tarskian Truth'. I shall examine them together in this section.

Hintikka has shown that IF logic is more expressive than standard first-order logic. Is IF logic still a first-order logic? Here Hintikka's opinions and those of the individuals writing about his work diverge.

If one only takes the domain of the variables into consideration, IF logic is defi-

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nitely a first-order logic, because its domain is solely made up of individuals. But appealing to other criteria suggests a different reply.

In his paper, Hodges points out that IF logic makes it possible to express generalized quantifiers. However, certain of these quantifiers possess a definition in second-order logic. For example, the Chang quantifier, 'There are as many elements x satisfying the unary predicate Px as there are elements in the universe', is equivalent to the following *explicitly* second-order quantification: 'There is a bijection such that . . .'. If one uses the criterion of expressive power, IF logic must therefore be classified as a second-order logic.

To this type of argument, Hintikka replies that IF logic is only a small fragment of first-order logic, namely that formed by second-order formulas where only existential quantifiers bind second-order variables.

In his paper, Feferman appeals to independent arguments to defend his thesis that IF logic is a second-order logic. The limited recourse to second-order considerations that Hintikka allows himself only suffices, Feferman observes, if we limit ourselves to talking about the *satisfaction* of the formulas of IF logic within *some structure*. But, such a limitation is hard to allow. Logicians want to be able to speak of the *validity* of the formulas of IF (satisfaction for *all the interpretations* of its non-logical symbols). But, as soon as we cross into that territory, we land squarely in second-order logic. Hintikka responds by showing that one can construe the valid second-order formulas as valid formulas of a *many-sorted* first-order logic.

Feferman expresses doubts as to the usefulness of IF logic presented as a system to codify mathematical reasoning. He argues that the examples Hintikka has borrowed from contemporary mathematics could just as well have been handled in first-order logic. Along the same lines, Wolenski judges the reform of set theory through IF logic not very convincing. Both logicians agree, however, in recognizing that their criticisms do not contest the usefulness of IF logic and the semantics associated with it when applied to other fields.

Hintikka claims the status of standard logic for IF logic, of which first-order logic would be but a particular instance. Hodges and Wolenski beg to disagree. Hodges complains that IF logic is too complicated to be promoted to the status of standard logic and Wolenski complains that IF logic lacks a deduction theorem, which makes it impossible for us to define IF logic as the set of consequences of the empty set.

12. Is semantics effable or ineffable?

This question is debated in three papers: that of Hans Sluga entitled 'Jaakko Hintikka (and Others) on Truth', that of Pascal Engel entitled 'Is Truth Effable?', and that of Martin Kusch entitled 'Hintikka on Heidegger and the Universality of Language'. I shall examine them together.

In 1967, Jan van Heijenoort distinguished between two conceptions of *logic:* logic as language and logic as calculus. In several articles, Hintikka generalized this distinction. He contrasted language conceived as a universal medium with language as a calculus to which various different interpretations can be assigned. He viewed the distinction as a watershed in twentieth century philosophy.

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Sluga underscores some important consequences of adopting the conception of language as universal medium. It entails the ineffability (inexpressibility) of semantics, which in turn entails the ineffability of truth.

Wittgenstein wrote, 'Propositions can represent the whole reality, but they cannot represent what they must have in common with reality to be able to represent it . . .' (*Tractatus* 4.12). If language cannot talk about the relationship that it maintains with the world, what is the status of the propositions of the *Tractatus*, like proposition 3.12, which talks explicitly about the propositional sign's 'projective relation' to the world? Wittgenstein recognizes that these propositions are not ordinary theoretical propositions, but rather are *elucidatory* propositions that must finally be recognized as senseless, when through them, on them, one has climbed out over them (*Tractatus* 6.54).

In his preface to the *Tractatus*, Russell envisaged another possibility: 'There may be another language dealing with the structure of the first, and having itself a new structure, and that to this hierarchy of languages, there may be no limit'. It is this method, that Russell caught sight of in 1922, that Tarski would use when he defined the truth of statements of the object language in another language, the meta-language.

However, Sluga observes, if one holds, as Frege did, that the concept of truth is indefinable because it is presupposed in the *use* of any attempted definition, Tarski's solution shifts the problem without solving it.

At the end of his paper, Sluga seems to adhere to the deflationary theory of truth according to which statements of the form 'snow is white is true' say no more (about the world) than does 'snow is white'. He contends that even if one succeeds in defining truth, such a definition will not teach us anything about the relation of our language to the world. In his reply, Hintikka challenges this latter statement by Sluga and claims that game-theoretical truth definitions can teach us something important about this relation.

What does one gain by replacing the deflationary theory of truth by the theory based on game semantics? Hintikka replies that his theory of truth does something that the de-flationary theory does not do. It tells us how one *shows* that the statements are true or false.

According to the truth theory based on game semantics, the truth of statement p is identified with the *existence* of a winning strategy for the player who seeks to verify p. This existence may not be known. As Engel emphasizes in his paper, the conception of truth based on game semantics is a *realist* conception of truth and is not, in spite of appearances, a verificationist or constructivist theory.

Engel shows the respect in which Hintikka's conception of truth is realist by arguing from the following example. Let us consider a statement of the form: (1) $(\forall x)(\exists y)(Rxy)$. Such a statement is true, Engel writes, if it is possible to find 'witness' individuals y depending on x such that $F[x, y]$. However, one can only *find* such individuals if there is a certain function f such that (2) $(\forall x)F[y, f(x)]$, where f is a Skolem function, namely a choice function of individuals. Thus the truth condition of $(\forall x)F[y, f(x)]$ is the existence of such a Skolem function. In other words, appropriate witness-individuals exist for a quantificational sentence s only if there is an array of Skolem functions for this sentence.

As Engel points out, one could even speak here of *truth-makers*. One is, therefore,

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quite far removed from Tarski, who defined truth as satisfaction *by all the sequences of individuals of the domain*, which implied, as Davidson noted, that all true statements are made true by the same fact, the 'Big Fact'.

Where are we as concerns the ineffability of semantics and the conception of language as universal medium? Do the notions of winning strategy and of verifier enable us to anchor truth and meaning in something outside of language? Not really, replies Engel, because these notions must already be understood by the speaker.

At the end of his examination of Hintikka's discussions of meaning and truth, Engel concludes by saying that the thesis that 'we cannot use language to get outside language' is one to which Hintikka is still committed.

In his paper, Kusch shows that if one adopts the conception of language as calculus, one does not really get outside language, even when armed with model theory aimed at interpreting it. Indeed, as Kusch notes: 'Varying semantic relations in model theory is not varying relations between language and an unconceptualized world; it is varying relations between language and a linguistically constituted artificial mini-world'.

To Engel, Hintikka replies that he agrees with Wittgenstein that the correspondence between language and the world is constituted by rule-governed human activities. To Kusch, he replies, in the same vein, that the correspondence between language and reality is constituted by the *use* of language and not by naturalistic relations.

13. Truth in IF. Has Hintikka really exorcised Tarski's curse? (Philippe de Rouilhan and Serge Bozon)

The definition of truth for formalized languages that we owe to Tarski involves a positive result, (1) it is possible to formulate an adequate definition of truth for the object-language L in metalanguage M, and a negative result, (2) it is impossible to define truth for L in a meta-language that is not essentially richer than L, which amounts to saying that a language cannot contain its own truth predicate.

In an article published in 1975, Kripke demonstrated that the impossibility described in (2) could be overcome under certain conditions. This important finding does not in any way refute Tarski's theorem of indefinability, but it restricts its scope. Kripke's article represented a major advance, but the problem dealt with was only partially resolved. Kripke succeeded in constructing a language that can contain its own truth predicate without generating the Liar paradox, but he did not show that we could do without hierarchies of language.

Hintikka took up the job that Kripke began and has gone further in carrying it out. IF languages that contain their own elementary syntax, write de Rouilhan and Serge Bozon, contain not only a truth predicate, but an *adequate* truth predicate. Hintikka's theory of truth represents a decisive advance in post-Tarskian truth issues for precisely this reason.

De Rouilhan and Bozon describe the difference between 'truth predicate' and 'adequate truth predicate' in these terms: the extension of the former coincides, for one reason or another, with the set of statements true in L. The extension of the latter is identical to this same set, but for (quasi) logical reasons.

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In particular, for the truth definition to be adequate, the two members of the convention T (which states that 'X is true in L if and only if p') must be (quasi) logically equivalent. It is because Hintikka's definition of truth satisfies this additional constraint, de Rouilhan and Bozon affirm, that it is more satisfactory than Kripke's.

The method used by Kripke to neutralize the theorem of indefinability does not free us from Tarski's hierarchy of languages. Does Hintikka's more demanding definition manage to do so and thus exorcize 'Tarski's curse'? The two philosophers state that it does not, at least as long as the language for which the predicate 'true' is defined is a language fundamental (see the definition of 'fundamental' on p. 692).

De Rouilhan and Bozon reason as follows. Having an adequate definition of the truth predicate in L is not enough. The presumed monolingual speakers of L should be able to formulate the criterion of adequacy and that would require them to be able to express the relation of quasi logical equivalence.

But that is impossible in L, which is a fundamental language. The task can nonetheless be performed by speakers of metalanguage M. Thus, in a certain sense, the criterion of adequacy remains ineffable for monolingual speakers of L. Or, to express this in the authors' own terms: 'No fundamental IF language contains its own model theory and [. . .] can express the model-theoretical criterion of adequacy of its own internal definition of truth'.

In my introduction, I said that Hintikka's replies to the papers contain many reformulations of his theses which improve the way they were initially formulated. The occasion arises here to give an example of this. In *The Principles of Mathematics Revisited*, Hintikka states that one can develop a model theory for powerful IF first-order languages while remaining in the first-order, independently of any questions raised by the sets and the existence of such entities.

That is definitely a bold statement. In his reply to de Rouilhan and Bozon, Hintikka is less trenchant. He admits restrictions to the self-sufficiency of first-order logic. He acknowledges that de Rouilhan and Bozon have conclusively established that not all meta-theory of an IF language can be done in that same language. He also grants that they have proved that logical truth in an IF language is not expressible in the same language, but he continues to deny that these findings constitute a threat to his claim that Tarski's hierarchy of languages is not needed.

According to Hintikka, the question as to whether such a hierarchy is needed for defining truth is answered by a proof that the truth predicate is definable in an IF language powerful enough to express its own syntax. But does this claim take into account the monolingual speaker argument?

14. Hintikka's generalizations of logic and their applications to science (Patrick Suppes)

For Patrick Suppes, the best way for Hintikka to prove the strength of IF logic would be to show that it can solve an important problem in one of the scientific fields. Hintikka's article entitled 'Quantum Logic as a Fragment of Independence-friendly Logic' partially, but very significantly, satisfies this requirement.

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In the above-cited article, Hintikka shows that Birkhoff-von Neumann quantum logic is interpretable in an enriched IF logic, notably by the introduction of a second kind of negation: contradictory negation '¬'. The significance of this result is considerable. As Suppes remarks, quantum logic ceases to be a separate domain. It becomes a sub-domain of IF logic which is, in turn, an extension of classical logic. Quantum logic at the same time ceases to be a 'deviant' logic.

Quantum logic has at times been criticized for abandoning certain logical laws (the principles of distributivity) solely in order to account for the structural properties of quantum theory. In the IF approach to quantum logic, this objection is no longer valid because, as Hintikka notes, the changes made to the laws of classical logic are motivated by reasons much more general than questions of physics, for example, by the concern to capture relations of dependency and independency that escape standard first-order logic.

Hintikka also points out that extended IF logic can be embedded in a suitable logic of probability, just as classical logic can.

There is, however, at least one case in which extended IF logic's being a *generalization* of classical first-order logic does not constitute an advantage. Suppes examines it closely. I shall look at it now.

In quantum mechanics, except for degenerate cases, there is no *joint distribution* of position and momentum for an individual particle. *Quantum mechanical probability spaces* take this particularity into account and do not, in this case, assign probabilities to this non-existent joint distribution, contrary to the *classical space of probabilities*, which does assign one, which is undesirable.

The space of probabilities associated with the *logic of probability* is the classical space of probabilities. Since extended IF logic is in agreement with the logic of probability in this respect, it has the same weakness as the latter. It assigns probabilities when this should not be done. There seems to be a tension, Suppes observes, between the generalization of classical logic given by Hintikka [via IF logic] in terms of probability and the reduction in the scope of probability in quantum mechanics.

To this very precise question, Hintikka provisionally replies by suggesting, not reducing the probability distributions, but restricting the events to which we assign probabilities.

15. A logical miscellany (Raymond Smullyan)

In his paper, Raymond Smullyan proposes a new logical reconstruction of controversial proofs (such as the ontological argument) and of famous paradoxes (such as the prisoner's dilemma). His analysis opens on to some unexpected theorems of the propositional calculus such as the theorem stating the equivalence between $p \wedge q$ $p \equiv (p \supset q)$. I shall, however, dwell on one particular aspect of Smullyan's method here: his analysis of *self-reference*. This analysis, in fact, gave rise to a very constructive response on the part of Hintikka.

In famous works devoted to logical enigmas, Smullyan has studied self-reference in depth. His analyses have shed light on difficult theorems like Gödel's first incompleteness theorem, in which self-reference plays an essential role. The formula that

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Gödel proves to be both true and unprovable is rendered in writings intended for the general public by 'I am unprovable'.

As intuitively clear as this rendering may be, Hintikka remarks, it distorts reality. The mathematical language used by Gödel does not in fact possess symbols like the pronoun 'I' to express self-reference.

It was to fill this gap in mathematical and metamathematical language that Gödel invented a way of numerically codifying symbols, formulas and proofs (as well as terms of metalanguage, 'theorem', 'proof', etc.) and combined them with a technique known since Cantor's time: diagonalization. Without going into detail, let us remember that the goal is to construct an arithmetical formula G, which is now called a Gödelian sentence, a formula that says: 'there is no proof of G'.

Gödel succeeded in proving G, a formula which, in one of its interpretations is an elementary theorem of number theory and which, in another one of its interpretations, is a metamathematical theorem about the provability of arithmetical propositions. As Hintikka notes, since formula G is a theorem of logic, it does not depend for its truth on the interpretation it is given.

Hintikka suggests the following analogy. Let us imagine that the movie actor Clint Eastwood is playing the role of Dirty Harry, a character in a movie, and in the film he makes statements about people in their mundane everyday lives. He could in this case speak about himself, and playing the role of Dirty Harry utter: 'In this situation even Clint Eastwood could not keep a straight face'.

The film analogy is a way of shedding light on the dual role that Gödel numbers (codified numbers) play in Gödelian sentences. As Hintikka points out, sometimes they say something about this or that number considered in its weekday function as numbers, at times they make a statement about themselves.

16. Induction, abduction and oracles (Isaac Levi)

In 1966, Hintikka solved a major problem that had arisen in Carnap's inductive logic. It showed how the latter's programme for inductive logic had to be modified to make it possible for universal statements to receive positive probabilities on the basis of data. For the next fifteen years, Hintikka continued to work in this area with his compatriots Pietarinen, Hilpinen and Niiniluoto.

In his paper, Levi reconstructs the development of Hintikka's ideas on induction and abduction by comparing them with his own ideas and those of Peirce. A general theory of rationality emerges from this reconstruction that sets out the relationships binding the key notions of inference, logic, reasoning, abduction, deduction and rational decision-making. I shall only discuss here what in Levi's paper leads to a better understanding of the conception of induction and abduction advocated by Hintikka.

Like Peirce, Levi holds that any inquiry begins with a stock of assumptions free from doubt. Unlike Peirce however, he maintains a clear distinction between conjectures conceived of as potential answers that might be true or false and assumptions free from doubt.

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Explicative reasoning that does not involve any change in commitments about beliefs, when going from premises to conclusions, must be distinguished, according to Levi, from *ampliative reasoning* which does involve such a change. Levi restricts the use of the term 'inference' to reasoning of the first kind.

Levi's ideas about logic reach well beyond deductive logic. That discipline not only seeks to identify the minimal conditions that rationally coherent states of belief should satisfy, it also aims to identify the conditions that rationally coherent states of probability judgments must satisfy. It must finally be concerned with the rational coherency of value commitments and the rational coherency of our evaluations. In sum, for Levi, logic is the discipline that formulates the standards of *rational decision-making*.

Peirce, Hintikka and Levi agree in saying that abduction, conceived of as a conjecture forming procedure, falls under the heading of ampliative reasoning, but Hintikka and Levi disagree about the nature of abduction. Hintikka, who acknowledges the difference between deductive reasoning and abductive reasoning, holds that the only rules that abductive logic has are strategic rules. Abduction does not, in Hintikka's opinion, have definitory rules. In concrete terms, that means that for Hintikka there are no norms for proper abduction.

Levi stresses that in this regard Hintikka departs from Peirce who required that conjectures generated by abductive reasoning satisfy the pragmatic principle. To be admissible those conjectures had to satisfy a minimal condition. They had to *be testable*.

Moreover, for Peirce, those making conjectures obtained via abduction must pronounce on the chances of the outcomes of the experiments intended to verify them and *support their claims with statistics*. Levi regrets that those norms for proper abduction are absent from Hintikka's work.

Levi shares Hintikka's current skepticism regarding the possibility of constructing an inductive or probability logic in the spirit of Laplace, Keynes, Johnson, Jeffreys, Carnap and Hintikka himself in his early days, but he considers tenable a less ambitious programme in which the probability logic would be defined by constraints (constraints of coherence, consistency and convexity).

In Hintikka's reply, one can point to the passage in which he emphasizes that Peirce recognized the eminently interrogative nature of abductive inference. By deliberately turning to the construction of a logic of questions and away from inquiry based on interrogation, Hintikka has therefore not for all that broken with his earlier work on abduction and induction.

17. From the logic of questions to the logic of inquiry (Matti Sintonen)

In the twentieth century, a logic of justification was commonly admitted to exist, but philosophers did not believe that a logic of discovery could exist. At the very most, philosophers accepted the idea of an ill-defined heuristics. In 1999, Hintikka published *Inquiry as Inquiry. A Logic of Scientific Discovery*. This book contained an article by him entitled 'Is Logic the Key to All Good Reasoning?' and 'Interrogative Logic as a General Theory of Reasoning' written by two others (I. Halonen and A. Mutanen).

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The ideas underlying these papers profoundly renew epistemology, philosophy and the history of science.

Anxious to avoid any anthropomorphism, sensationalist philosophers countenanced the idea that nature's answers to those questioning her always took the form of an atomic statement. But, Sintonen remarks, this apparently obvious way of confining the complexity nature's answers quickly beomes problematic. Let us take, with Hintikka, the classical example of controlled experiments. Here, the question asked of nature takes the following form: 'How does the variable observed depend upon the variable x?' The answer that inquirers expect is an answer that will enable them to know the functional relation binding the two variables. However, Sintonen notes, knowledge of an infinite list of arguments and variables is not enough. Inquirers want to know more. They want to know what the function is.

Sintonen sees the nineteenth century philosopher William Whewell as a precursor of Hintikka. Whewell accorded conceptual presuppositions an important role in determining the function corresponding to experimental or observed data. How is it that, using the same observed facts, Kepler discovered that the planets' orbits are elliptical, while Tycho-Brahe did not? Whewell answered that what made the difference was the former's acceptance of certain conceptual presuppositions concerning the properties of ellipses. On the problem raised by the surprising mathematisability of laws of nature, I refer readers to Gilles Dowek's book, *Les metamorphoses du calcul*, published in 2007, which proposes a new solution. Hintikka acknowledges the affinities with Whewell that Sintonen attributes to him, and takes the opportunity to state the role of the logic of questions that he proposes. In Whewell, the need to resort to conceptual presuppositions is merely *affirmed*. In Hintikka, it *derives* from the logic of questions.

'Why-questions' play a central explanatory role in science and in everyday life. Hintikka, Sintonen notes, distinguishes two major families of explanation: explanations as subsumption under a law; and explanations turning on dependency relations. The latter are more satisfactory than the former, but it is difficult to formalize them with just the resources of the logic of questions.

In his reply to Sintonen, Hintikka responds to this objection and presents his present views on the relationship between *explanandum*, initial conditions and background theory. He also sets out the role of interpolation theorems within this context.

18. Confirmation, information and content (Theo Kuipers)

Theo Kuipers' paper assesses research on confirmation and information maximization. In the first part of his essay, Kuipers rigorously defines the notions of deductive confirmation, probabilistic confirmation and structural confirmation. Then he tackles the problem raised by the definition of 'degree of inductive confirmation'.

In the second part, he is interested in different kinds of information and their relevance to explanation and generalization. In this second part, readers will find a very illuminating exposition of Hintikka's goals and declarations about choices between rival hypotheses.

In the third part, Kuipers positions himself with respect to Hintikka. While

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Hintikka tries to drive a wedge between explanation and generalization by emphasizing the distinction between (logarithmic) information and content, Kuipers is more concerned to distinguish the structural aspects of inductive aspects of probability and information.

This detailed comparison opens onto some specific recommendations. Hintikka limits himself to taking into account a single probability function. Kuipers thinks, however, that at least two probability functions must be taken into account: the subjective probability function and the structural probability function. The relative importance of the two, he adds, differs depending on whether the objective is generalization or explanation. Inductive aspects must take precedence over the structural aspects in the first case. Structural aspects must take precedence over the inductive aspects in the second case.

19. Questioning art (Michel Meyer)

Hintikka has detected and explored analogies between artistic movements and philosophical movements. In 'Concept as Vision', he draws comparisons between Cubism and Phenomenology. The role of aesthetics in Hintikka's work has scarcely been studied. Happily, Michel Meyer fills this gap.

Meyer is intent upon explaining basic movements that run through the arts and countries and give birth to literary genres and styles. He does this perspicaciously starting from the tripartition *ethos, logos* and *pathos,* which, for him, as for Hume, corresponds to the three most fundamental questions of the human mind: questions about the I, the world and others.

In Meyer's paper, one sees an unspoken question appearing between the lines. Hintikka formulates it in these terms in his reply to him: 'Is some approach like the interrogative model applicable in the realm of the aesthetic?'

20. New developments

Hintikka's work is today inspiring much more fruitful research than can be presented here. I would, however, like to mention Gabriel Sandu's new appendix to the book *Les Principes des Mathématiques revisités*, the articles devoted to Hintikka's work in *The Age of Alternative Logics* and Denis Bonnay's findings. Establishing a connection between the games used by Hintikka to define the conditions of truth and falsehood of formulas and proof games involving the search for truth, Bonnay has developed a proof semantics for classical logic that makes it possible to interpret the proofs as winning strategies over game semantics analogous to Hintikka's games (Bonnay 2004).

Paul Gochet
University of Liège, Belgium
Translated from the French by Claire Ortiz Hill

https://doi.org/10.1177/0392192110365274 Published online by Cambridge University Press

Notes

1. For a general introduction to epistemic logic, I refer readers to *Epistemic Logic* (Gochet & Gribomont 2006).

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