

## Distinctio Talks

by Jure Zovko

### Logic as the immune system of the mind

A conversation with Johan van Benthem<sup>1</sup>

Before answering your questions, let me say that on first reading, I found them somewhat challenging, since they did not map straightforwardly to my own mental space as a logician. But on a second reading I found the questions posed here highly rewarding for just that very same reason. So, with pleasure, I will now follow the trail markers that you have planted.

1. Logic has always been an important part of epistemic reasoning in the history of philosophy. Jan Lukasiewicz has claimed that the principle of contradiction had a primarily practical and ethical significance because it served as the only tool against error and falsity to remove contradictory judgments from argumentation and to eliminate errors of thought. Thus, the principle of contradiction enables (and only it can enable) a victorious struggle with various falsehoods, and therein lies its full significance. What do you have to say about this?

I warmly endorse this. While people often stress the role of logic as helping us pile up knowledge or truths from a stock that we already possess or construct new theories adding smoothly to our conceptual inventory, I think that the critical function of logic is equally important. We must ‘agree to disagree’, not in the bleak sense of leaving contradictions and disagreements politely unsolved, but in the sense of taking them seriously and doing something about them. That is why I am somewhat suspicious of paraconsistent logics that seem to remove this urgency. Of course, our thinking and theorizing is full of contradictions, perhaps even necessarily so given our bounded cognitive powers, but we should not encapsulate contradictions, but address them as soon as they come to light.

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I also like the fact that your opening question is about connections between logic and epistemology because the entanglements of the two areas fascinate me more and more. And I do not just mean epistemic logic here as a tool for analyzing what philosophers have said about knowledge and information, but also the various knowledge- and information-based views of the basic notions of logic itself that have kept emerging over the last century.

2. Continuing with Lukasiewicz, he claimed in his farewell address at the University of Warsaw (in 1918) that classical logic exercises coercion on the human mind due to the necessity of accepting self-evident principles and theorems. What led him to develop his three-valued logic? Many other logicians decided on a similar approach for various reasons connected with undecidability (Kleene) or paradoxes (Bochvar), and there have been other approaches that abandon the notion of truth values altogether (e.g., fuzzy logic). At congresses of logicians and epistemologists nowadays, it is striking that there is an intense debate regarding logical monism and logical pluralism. How do you see this issue? Is there such a thing as „one true logic“ or should various kinds or approaches in logic be favored in various circumstances? In other words, should we adopt a monist or a pluralist (instrumentalist) view of logic? Furthermore, is the position of logical pluralism a threat to the stability of epistemological models?

Yes, in his own practice, Lukasiewicz sometimes sang a different tune from classical logic. Of course, there can be good arguments for working with more truth values so long as they have a clear interpretation. However, for the record, I do not think that Lukasiewicz' famous analysis of Aristotle's Sea Battle argument in terms of three truth values is a convincing instance. There are several more enlightening classical solutions for that puzzle, and using the third value may be just a sign of laziness in not analyzing other key features of the scenario.

But now the big question that you pose: pluralism and different logics for different purposes. I do think that using different logics for different purposes can make sense, and that goes back to my appreciation for Bernard Bolzano whom I read as setting the task of logic as the systematic charting of natural styles of reasoning, a view I also

see in Peirce. But I should elaborate what I mean by this, and this comes in three points.

First, the task at hand should always be clear and it should explain why the logic is as it is. This is what can be done for, say, intuitionistic logic as a logic of constructive proof, or of quantum logic as a logic of empirical observation in the quantum world. But to give a critical example, after decades, it is still unclear to me in which sense the commonsense notion of relevance supports the actual mechanics of ‘relevant logics’. Next, we should never just accept the plurality as a family of different ‘lifestyles’, we should seek the underlying unity. To me this unity is provided by the many translations that exist between different logical systems, a topic that I could say much more about, and which is still in full development with many surprising discoveries no doubt awaiting us. In this way, different-looking logics can in fact have the same abstract informational content in terms of expressive power and consequence relations, even though they may differ in their pragmatic value as suggestive alternative representations of that content and how it can be manipulated or modified. Finally, we should never accept that one proposed logic is the unique media outlet for a given practice, but actively foster the search for alternative approaches (a sort of ‘meta-pluralism’ if you wish). For instance, I find it striking that many proposed non-classical logics, even intuitionistic and quantum logic, have equally attractive classical counterparts with other kinds of vocabulary that describe the same reasoning practice in different formats.

I often get asked by students what is in my heart, rather than in my mind and my diplomatic published prose on these matters. Is good old classical logic the one true logic? Listening to my heart, I feel that it is indeed the ‘mother logic’ for everything, including the development of non-classical logics. But there you have it, I have already confessed too much.

3. On a similar note, Gentzen has shown that his construal of intuitionistic logic had the feature of being the “one true logic” because it conformed to the ideal of his Int-Elim style. This further led logicians like Dummett to claim that intuitionistic logic is the “one

true logic”. As you were one of the editors of the seminal volume *The Age of Alternative Logics*, how do you see this issue?

I can be shorter on this now. Yes, in terms of proof theory, intuitionistic logic, or just as well, weaker linear or other constructive logics are very well-motivated. Moreover, this feeling is supported by strong evidence like the beautiful Curry-Howard isomorphism for such proof systems which I have used a lot in my work on categorial grammars and their semantics for natural languages in the 1980s. But to turn this into a sweeping claim that intuitionistic logic is then the one true logic is an armchair flight of fancy: I have never been convinced by Dummett’s claims that it offers a universal theory of meaning beyond the setting of constructive proof or computation. On “The Age of Alternative Logics”, a very pleasurable collaboration with colleagues and friends, I would read this book title as standing for the moderate pluralist views I have explained above. Or less seriously, if you think of the title as echoing “The Age of Aquarius”, you should note that the latter song described an era, and in fact an era that would come to an end as the astronomical constellations progress through the zodiac.

4. Some prominent philosophers (Leibniz, Kant, Wittgenstein) have particularly emphasized the transcendental dimension of logic. In Wittgenstein’s *Tractatus* (6.13) we read, „Logic is not a doctrine, but a reflection (*Spiegelbild*) of the world. Logic is transcendental.“ It is further said that logic is „a scaffolding (*ein Gerüst*) of the world“ (TLP 6.124), or „the boundary of the world“ (TLP 5.61) Our meaningful propositions occur in a logical space, from experience we know whether they are true or false. According to Kant, we have a similar insight that the transcendental dimension of logic is the condition for making judgments, while experience remains the criterion of true and false. Do you think that logic actually has a transcendental role or dimension in our cognitive process?

You are raising some serious issues here. What is the ‘deep status’ of the laws of logic? Are they the most general features of the world that are prior to our experience of it, or are they perhaps a structuring property of our thinking about the world, perhaps even one that reflects the particular nature of the human intellect? I must confess that I keep wavering on these issues. I do feel that the compelling

nature of logical laws means something objective that is not up to our subjective judgments to manipulate. But whether this compelling force is reality speaking or rather imposed by the structure of our minds is something that I find hard to tell. Ideally, I would think the first: logical laws govern reality and given our long history as a species, this is reflected in the structure of our minds, since that survival depended on a harmony of reality and intellect. However that may be, I believe that our ability to think logically is not just a philosopher's conceit, but itself a natural phenomenon that is in line with what we can learn from cognitive science in both its synchronic and diachronic varieties.

5. The American philosopher of science, Michael Friedman, has claimed that the philosophers of the Viennese circle successfully continued Kant's idea of combining logic and experience, elaborating on philosophy as a strict science. Otto Neurath has often claimed that physicalism *sensu stricto* is a „through-logicized empiricism (*durchlogisierter Empirismus*)“. Representatives of empiricism in philosophy of science (Bas van Fraassen; Ian Hacking) have denounced this tendency of *durchlogisierung* of reality as a relapse into metaphysics. What is your position in this respect?

I confess that this is not something I have really thought about. On the whole I would be wary of metaphysical views about or uses of logic insofar as these views claim to 'carve reality at the joints'. I find this incredibly pretentious, and well out of line with the long historical development of the field of logic which has seen so many major conceptual changes. To amend my previous answer a bit, I believe that it is also crucial to the human intellect to keep questioning notions and theories and come up with better ones. I do not think that logic should be an exception, and any prophecy-style view about stating things once and for all just bothers me since it leaves no room for the intellect of the generations after us.

6. Popper turned the philosophy of the Vienna Circle upside down: instead of verification, he offered falsification, he replaced induction with deduction, and sees the solution of scientific research in logic, which he calls the „logic of discovery“ (*Logik der Forschung*). Popper's critics (Hintikka, Feyerabend) countered him, stating that there is no universal logic of research and, *ipso facto*, no

universal scientific method. Proponents of Popper's philosophy see in his logic of research more similarity to Kantian judgment than to epistemic logic. Popper has compared his logic of research to chess games. Do you think there is a universal logic of discovery?

I would think that this sense of 'logic' is very different from what we had with the previous questions. It is not about some system of logical laws governing the world or our minds, but about rational procedures for inductive learning and perhaps even true discovery. This makes the relevant sense of logic more 'dynamic', a topic to which I intend to return in answer to your later questions. In this setting, I doubt whether there is an interesting universal dynamic logic of discovery that we can just apply, though there are some formal results about 'universal' learning methods when we see learning as involving belief revision.

Which brings me to the Popper I like: the one emphasizing falsification and learning by giving up refuted hypotheses. I believe that this is indeed the best method for science to proceed, but also for our daily lives. To me our human intellect shines at its brightest, not when we proceed placidly from truth to truth or from knowledge to knowledge, but when we spot errors and perform revisions, sometimes small, sometimes radical. To me this creative revision perspective is hugely neglected in many parts of philosophy, such as epistemology or philosophy of language, which tend to focus on describing or insuring correctness rather than on the dynamics of correction. It is that constant dealing with new challenges which is a powerful way of unleashing creativity, and since logic plays an important role there, I have long been on record for the position that "Logic is the immune system of the mind".

7. You started to work on modal logic(s) early in your career and have contributed much to the field (it is enough to mention van Ben-  
them's Theorem). According to you, what was the turning point for modal logic(s) to be accepted as a justified project, as it is well known that some logicians (like Quine) were very skeptical of modal logic(s) in the initial stages of their modern development?

Was the affirmation of modal logic(s) due to Kripke's work on semantics for modal logic(s) or were there some other reasons?

I cannot speak with authority on this sea change since I was a beginning student when this happened. Kripke's work was important in that it showed how modal logic could have a precise semantics, support mathematically significant theorems, and throw new light on old topics such as metaphysics or intuitionism, while Hintikka reinforced this influence with his seminal work in epistemology. One should probably also mention early deontic logicians from this era, whose semantic contributions may have been underestimated. But an equally important influence on me personally was Arthur Prior, whose work on tense and time was more concrete, and who showed new ways in which modal thinking could go. By the way, Quine's famous objections just seemed based on spinning a clever web of confusions to me, something I still believe, even though (naturally) my respect for what aging gentlemen have to say has grown over time. But the staying power of modal logic as I see it owes much more to later developments. In the 1970s, linguists started using modal logic-inspired models in formal semantics, computer scientists discovered that modal logic is a good vehicle for logics of programs and processes, while economists started using epistemic logic. This hugely extended the impact of the paradigm, as you can find recorded in my textbook "Modal Logic for Open Minds". At the same time in the 1970s, a whole generation of talented people started developing the mathematical foundations of modal logic and its deep connections with algebraic logic, topology, and even the Gödelian foundations of mathematics. The richness of this mathematical structure and its in fact still ongoing theoretical exploration was another powerful component in the success of modal logic, and it has transformed our understanding of what this field is about, for instance, by connecting it firmly to classical 'standard systems' in logic. Just read the standard textbook by Blackburn, de Rijke & Venema, compare it with the Hughes & Cresswell of my student days, and you will see what I mean.

The realm of modal logic keeps expanding. Just recently, radically new 'minimalist' theories of the basic grammatical structure of natural language developed by Paul Pietroski turned out to be, completely unintendedly, systems of modal logic. Modal structure and

modal perspectives form a natural conceptual nexus, they just will keep popping up.

Of course, with all this I am not claiming that modal logic is the most important province of logic. Even so, my students sometimes complain that every subject I analyze turns out to go in this direction, and then ask me in a spirit of defiance: “Must there always be a modality lurking behind the corner?”. To this, naturally, my answer is: “Certainly not.”

8. Using your professed love for modal logic, let’s have another question related to it. It has become well known that the Ontological Argument for God’s existence is linked with modal logic, especially after Malcolm’s famous paper in which he claims that even Anselm himself offers a modal version of the Ontological Argument in *Proslogion* 3. This was of course further amplified through Plantinga’s formalisation of the argument in S5. Consequently, this question inevitably branches in two ways. How do you see the S5 system? Is the axiom that possibly necessary P entails necessary P an acceptable axiom and is the S5 system acceptable or should it be replaced by a weaker system? Furthermore, what is your take on the Ontological argument, especially as presented by Frege, Gödel and Plantinga? Do you see it as unavoidably flawed or as a good piece of reasoning starting from arbitrarily established premises?

Modal proofs for the existence of God have fascinated me ever since I first encountered them as a student. I have pored over many versions, and I even had the good fortune of hosting Alvin Plantinga in Amsterdam when I was a young assistant professor teaching a seminar on his book “The Nature of Necessity”. Generally speaking, I am wary of substantial theological conclusions drawn from a few abstract premises with some logic engine, even when, as in recent years, this logic engine is a computer whose deductive powers dwarf that of humans.

I find that either the theorems that emerge are over-interpreted, or the full force of the assumed premises is not realized. As for the latter case, consider the S5 axiom you mentioned that possibly necessary truth implies necessary truth. This axiom fails for many modal notions (e.g., few people would accept it for the epistemic modality of knowledge), but if we accept it for metaphysical modality, we are

really assuming a very strong existence principle of Plenitude akin to “if a proof could exist, then it does exist”. Assuming such a principle will populate the universe with lots of abstract entities, not just God. Even so, my fascination is still alive, and I have never found closure on this topic. First, in mathematics we do get what feel like substantial insights from simple evident axioms, why could not theology also produce such discoveries? After all, it too can be a very abstract style of thinking from postulates. And even with my logician’s dismissal of substantial conclusions from mere logic alone, I sometimes worry about a certain asymmetry. I do believe that the great logical paradoxes offer simple arguments that bring to light fundamental limitations to what our thinking about truth, proof, and other notions can achieve. These conclusions are then substantial insights of impossibility, stating what cannot exist: such as decidable substantial logics of quantification, or complete proof systems for mathematical truth. But if I accept that relatively simple logical thinking can produce sweeping non-existence insights, why could not I accept that it could also (in the minds of future thinkers) produce equally sweeping existence insights? Well, more can be said about this asymmetry: I only wanted to show that my mind is not yet made up. My quick dismissal of the automated deduction case is another example. Most interesting deductive arguments with striking conclusions that have been found in philosophy so far involve short proofs. In logic, think of the few-line proofs for the Liar Paradox or the Russell Paradox. Perhaps there is still a whole world of striking conclusions waiting to be discovered as we explore longer and longer chains of reasoning, a bit like travelers in outer space with the computer as our space-ship.

There you are. I hope that I have not managed to arrive at a sum with value zero when you add up the first and the second parts of my answer. In any case, your question also brought back some vivid personal memories of encounters between logic and theology. I remember taking Plantinga to the Free University in Amsterdam, a bulwark of Calvinist theology at the time, where his talk (highly appreciated earlier at our non-religious, though devoutly socialist, University of Amsterdam) was not well-received. The theologians in the audience considered proofs of the existence of God a threat to the living essence of the Faith, which according to them, was to

live with doubt, and conquer one's doubts on a daily basis. What resonates with me here is the importance of a 'penumbra of doubt' around one's intellectual views, keeping things open for revisiting, and suggesting a certain modesty. That penumbra in fact surrounds most of my answers to your questions. Of course, what the audience also meant was that religious life should depend on both hearts and minds. That is definitely true for many things that matter in life, including academic endeavors.

9. Since Peirce, abduction has been considered a successful model of the connection between logic and epistemology. Almost all epistemologists emphasize the indispensability of abduction but disagree on whether it is a form of searching for the best hypothesis, whether it is equivalent to inference to the best explanation, or, again, whether it is a form of preliminary judgment in the search for the best explanatory option. What is your opinion on abduction?

I find Peirce's thoughts on logic in its broadest sense extremely original and inspiring, and to me, the true picture of what contemporary logic can be and do only arises when one juxtaposes the by now iconic Frege with this American contemporary. Even so, I have no considered view on abduction and its logical status, so let me keep this answer short for once.

10. One particularly influential approach to logic is the game theoretic approach. In contemporary times, this approach was mostly found in the work of Leon Henkin and Jaakko Hintikka. Can you tell us a bit more about the difference between quantifiers in classical first-order logic and the independence-friendly approach? Is the independence-friendly approach the right approach to quantification, or is it just more suitable for some particular purposes?

Well, you are talking to the author of a 548-page monograph called "Logic in Games" here, which presents both uses of games to analyze logic and uses of logic to analyze games and game theory in one grand narrative on the many-sided interface of logic and games. So, be careful what you unleash with this question!

Yes, games have long been used to elucidate major notions in logic, but I think that you should also mention Lorenzen, Ehrenfeucht and Fraïssé who did seminal work before the authors you cite, and

whose work has arguably had much greater repercussions in logic today. This sounds like just a bold claim, but read my book...

Now to your specific question. Quantifier patterns in first-order logic express certain Skolem-type dependencies between variables which can be interpreted as winning strategies for a Verifier in evaluation games for first-order formulas in given models played against a Falsifier. Hintikka claimed that natural language, mathematics, and even quantum physics also needed dependence patterns between variables that do not occur in first-order logic, but can only be represented when we extend the syntax to break the automatic dependence of later quantifiers on earlier ones in linear syntax. That led to his discovery of IF-logic, a fragment of second-order logic which can indeed express such patterns.

What do I make of this? Hintikka's technical work was highly original and provocative (he was a very anti-mainstream mainstream-accepted philosopher), so were his views on natural language semantics, and I truly like his general philosophical views on the role of all this in his 'Socratic epistemology'. Even so, there are lots of problematic features here. First, I do not find the natural language examples or the ones in the foundations of mathematics very convincing. But as a good logician whose heart is pure, I would be willing to forego such qualms about concrete applications if the system itself were elegant, deep, and inspiring. But I doubt that. I find the outcome that we arrive at a non-classical highly complex second-order logic with some pretty unreadable syntax very disturbing, since this does not fit my intuitive understanding of the notion of independence, and I suspect that these features are rather artefacts of Hintikka's particular formalization. Also, the lack of a good proof theory for IF-logic is ominous since one normally likes some harmony between the semantics and the deductive engine. A better version in this respect is the later dependence logic of Jouko Väänänen which does two things: it shifts to dependence as the basic notion, and it dramatically improves the syntax by introducing explicit statements about dependence (and where needed: independence) of variables. But even that system is second-order and non-classical, technical features which I see as extraneous to what dependence is about.

My own view, developed in recent work with Alexandru Baltag, goes back to my technical work in the 1990s with Andréka & Németi

on the decidable Guarded Fragment of first-order logic, and to my philosophical fascination since the 1980s with the different notions of ‘information’ enshrined in epistemic logic and Barwise & Perry’s Situation Theory, where the latter was about informational correlation and dependence. We should start afresh, and first rethink what dependence and independence of variables mean in first-order logic. What we then find is that a natural base form of first-order logic which makes no prior decisions on which variables are dependent and which ones are not is decidable in models with state spaces that need not contain all mathematically possible assignments. If we insist on making all variables independent, as happens in Tarski’s by now canonized semantics, the system of validities becomes undecidable, though it is still completely axiomatizable of course. The higher-order logic versions arise only when we study a further phenomenon that is interesting but much more complex: the ways in which dependence and independence patterns can change when we change the current state space of possible assignments. This happens for instance with causal interventions or commitment to strategies in games: all ways of changing a given dependence structure. But to me, the appropriate illuminating logical syntax for that would be dynamic modalities for model change.

As you can see, this is a total conceptual reconfiguration of IF-logic, but one which I believe to be much closer to how the ubiquitous notions of dependence and independence function. What do I retain from Hintikka then? His seminal intuition that dependence and independence are such important notions that they deserve admission to the pantheon of basic logical notions, as against philosophers who keep trying to put a fence around a small and never-changing set of truly ‘logical constants’.

11. One of your greatest achievements in the field of logic research is the Logic of Time. Do you see, in this field, a possibility for dialogue with the classics of philosophy that have taken time as their most important theme, Kant’s schematism and time, Heidegger’s temporality of reality and temporalization (*Zeitigung*) of practice; or Augustine’s model of overcoming contingency?

The “Logic of Time” book developed two ontologies for time: point-based and period-(interval-)based and studied their connections in

great detail, including logical languages for accessing the two. This work was inspired by a number of things happening in my world back then: the emerging interest in linguistic semantics in event-based rather than point-based models for time, the interest in interval-based models for common sense reasoning in AI, and my gradual discovery of earlier work in philosophy by Russell, Wiener and Whitehead on how the worlds of science and commonsense interface and interact.

There are also some occasional excursions in the book to philosophers like McTaggart or Kant, or to medieval puzzles in temporal reasoning. However, your question reminds me that I should have done much more than just these light forays. I am all for the dialogue that you mention, if only as a way of confronting logical analyses like mine with the richer register of sensibilities of philosophers like St. Augustine or, say, Bergson or Heidegger.

12. From a pedagogical point of view, you are one of the founders and main figures of the Logic in Action project, which is supposed to present the field of logic in a modern and accessible way to both beginners and people with some expertise in the field. Can you tell us something about the project? Has it yielded the results you expected from it? Related to this, has logic firmly established itself as an interdisciplinary framework that extends into multiple disciplines (philosophy, mathematics, computer sciences, etc.) or is it inextricably linked to one of these disciplines, with others being a particular application of logic? If yes, which field would this be?

I would not see the “Logic in Action” project as primarily didactic or educational. It reflected my interest in Logical Dynamics, which I see as the philosophical view that we should move from the exclusive focus in logic on static notions and attitudes to a parallel study of the logical structure of the actions and processes that create and modify these notions and attitudes. I regard this as entirely similar to the duality of static and dynamics that created modern physics. My long-standing interest in dynamic-epistemic logic is one particular implementation and exploration of this dual aspect view, and so is my work on logic and games, and you can see the logical dynamics theme illustrated in great detail in the volume dedicated to my work in the Outstanding Contributions to Logic series.

But yes, this dynamic view is congenial to teaching and learning, since these are two important examples of information flow that exhibit logical structure. The project has yielded a good deal of basic research plus an open source textbook “Logic in Action” which presents basic logic in this style. But like most funded projects, perhaps the most important results were the people who participated and went on to academic positions in various places.

But your question has another thrust: what about the outreach and the positioning of logic? Here I cannot claim any strong influence for my project since it seems just a basic fact that logic today sits at an interface of many disciplines: classical parents like philosophy and mathematics, but also more recent friends like computer science, linguistics, and even to some extent the behavioral and cognitive sciences. And the continued success of an organization like the Amsterdam Institute for Logic, Language and Computation shows that this combination makes sense and can work. Of course, sometimes this seems like a form of polygamy where the various partners are not ‘interconscious’ (philosophers sometimes find the thought abhorrent that computer scientists could be great minds that can teach them something, and the same is true vice versa), but I think that logic can and should play more of a role in carrying powerful insights across disciplines, and that is also the spirit of the logic programs at the other universities where I am active: Stanford and Tsinghua. The fact that we keep attracting students with this broad outlook also seems significant to me. As I often tell them: “you are not a set of interdisciplinary scatterbrains, but a natural kind”.

Let me quickly set the ambitions for this straight. Logic is just one academic unifier and connector, so is mathematics, and so is philosophy. And I am also not saying that these unifiers are more important than the separate disciplines between which they operate. I often think of them as spices: they make the dishes that they are added to tastier and perhaps better-preserved, but only the very strong can live on a pure diet of pepper and nutmeg.

My view may sound modest and reasonable (at least, it does to me), but it has fundamentalist enemies who think all this waters down logic from its mathematical heartland or its philosophical heartland: take your pick. Here I do have a strong and perhaps not so modest conviction to add to what I said: seeking to foster this broader role

is not the end of logic, it rather seems the only viable future that my discipline has if it is to survive in the long run.

13. Do you see a danger in postmodernism that our traditional logic-based reasoning will be abandoned? Especially given there is more and more talk of post-truth conditions.

I have no such fears at all. Logic is everywhere: in the realities of fundamental science, in the life-saving treatment that you seek from your doctor, in establishing basics of intercultural communication in my work between China and the West, and so on. And this is just one aspect of the broader power of rationality and reason in our world.

Of course, there can be temporary threats. As a young philosophical logician in Amsterdam, I was confronted by Marxist students prophesying the end of logic as irrelevant to the best interest of the working class. Some of those very same students, now become high school teachers of philosophy, told me that their most satisfying topic was teaching elementary logic and seeing young minds light up. Right now, we hear a lot about the end of logic and its replacement by blind machine learning. But that rhetoric has already been long overtaken by new fundamental research where we can even show how, under the right causally faithful state space reductions, machine learning systems turn out to learn exactly what logical models have said all along. Perhaps this is just the inductive reasoning of Russell's chicken, but all challenges to logic in my lifetime have only seen the field bounce back more strongly.

The greater intellectual threat today has to do with your first question about contradictions and the art of dealing with them. The pursuit of logic as I see it requires a protected zone of critical free-thinking, where we can safely scrutinize and contradict whatever opinion is advanced, something that universities have provided since the Middle Ages, sometimes in the face of extreme political and religious pressures. If, for whatever reason, universities no longer guarantee that freedom to question and contradict, a lot of what makes intellectual life worthwhile is going to fall away.