

Where is Logic Going, and Should It?

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1 Mixed Feelings

Lenin wrote his famous book *What is to be Done* (surely the inspiration for our editor's choice of a title) in 1902 because he felt that the socialist movement had stalled half-way. And the rest is history... Are things at a historical juncture in philosophy, with serious problems that require drastic solutions? Sometimes, I do. In April of 2004, I attended the Spring Meeting of the American Philosophical Association in Chicago, and having said my own piece, I went to other talks on offer. One of the first was in a logic session concerned with, essentially, the counterfactual issue of what Frege would have answered if somebody would have asked him if... Then it suddenly hit me that, after decades of milking every sentence of Frege's for all its meaning (and often more than that), we were now moving into a first counterfactual level of speculation – and I had an oppressive vision of centuries of ever more nestings ahead of us, about what Frege would have said when confronted with the n -th counterfactual, and so on, until the end of time. Fortunately, the Chicago Hotel was well-provided with anonymous exits. I escaped into a beautiful early spring day, and walked along Lake Michigan with its wonderful shade of light blue that made me feel at peace and attuned to reality, even though I could not begin to describe today just what hue it was that moved me so. Seeing the Chicago skyline, including that counterfactual hotel, at a safe distance from the lake was deeply satisfying. I had made my escape. But how many people do? Some parts of modern philosophy that I can see suffer from a 'locked-in syndrom' with increasingly abstruse and uninteresting issues.

But misery can be just local. Yet another striking feature of modern philosophy is its *fragmentation*, and I could not even begin to claim I have a view of the whole: whether bad, or good, or ugly. And anyway, I see myself as a logician, and not as a real philosopher. Since I took two degrees, one in philosophy and one in mathematics, I never belonged entirely to either community – and I have learnt the modern logical point that these adjectives are non-monotonic. You are a 'mathematician' if you know only mathematics, but you lose that epithet if you know *more* – and the same applies to being a 'philosopher'.

2 **Reset: Positive Experiences, but only with a Stance?**

And yet, philosophers have written things, and keep writing things, that suddenly show our familiar world in a different light. As a student, this happened to me through encounters with texts that were not even on my official reading list. Old friends include Ryle's *The Concept of Mind*, as a liberating example of analytical thinking about oneself and one's cognitive activities, Prior's collections of studies into temporal reasoning, such as *Time, Tense, and Modality*, with their quiet but persuasive blend of logic, philosophy, and historical erudition, Habermas' *Theorie der Kommunikativen Kompetenz* which combined themes from continental and analytical traditions into a new view of what genuine dialogue and debate are about, or the Rawls–Nozick books (*A Theory of Justice*, and *Anarchy, State, and Utopia*) as a show-case of high-quality debate about our society, whose different stances transcend the usual political bickering. And such positive experiences persist. Amidst all those secondary publications reverberating with ever smaller amplitude in the system for decades after some initial 'famous paper', or mindless 'paradox' or 'puzzle' engineering without a larger vision, one sees the occasional flash of a truly new idea about an old theme, or a new perspective on the existing order in science or society.

What all this adds up to, though, is not an exclusive preserve for philosophers. They may have 'a league of their own', but not necessarily a country. Indeed, I see philosophy as a *modus operandi* without a special topic. Its territory is The World: a broad arena where one meets not just philosophers, but also psychologists, linguists, economists, computer scientists, and indeed people of sense from any walk of life. Admittedly, some of my most clever philosophical colleagues try to stake territorial claims, say, to the area of 'common sense' or 'good behaviour' – as a sort of Papal States where the nobility of the mind also has worldly jurisdiction. But to me, philosophy is a *spice*: it enriches things that might otherwise be bland – but it is usually a bad idea to eat your spices on their own... Now you may say that this is a strange stand for a logician, who has taken a vow to study methods *per se*, chastely staying away from the wear and tear of the realities of reasoning. So let us go to my current views of logic in a moment. They are becoming more content-oriented.

But before switching to upbeat mode, let me also illustrate the humiliations threatening a purist methodological stance. Recently, I participated in a national radio broadcast on new developments in Academia, together with a mathematical physicist and a historian of medieval literature. My two colleagues spoke about abstruse things like dimensions in

string theory and interpreting medieval manuscripts, while I talked about the surprising, and exciting subtleties of ordinary language and communication. After the interview, our interviewer turned to me. "I did not want to embarrass you while we were on air, but there is something I cannot understand. You seem like a clever person to me. So, why do you choose to waste your life on superficial issues like how people like you and me talk or think, while you could contribute to real issues like understanding the Universe, or Art?"

3 The Case of Logic: the Agenda To-day

So, let me now turn to modern logic, my own field of endeavour. Here, too, red-hot printing mills are spewing out immense amounts of papers, monographs, and even whole Handbooks – and by every measure of quantitative output, the field is doing fine. But as in general philosophy, much is business as usual, in mathematical and philosophical logic, without a broader vision at stake. I have discussed the current logic–philosophy interface in van Benthem 2005, trying to see some grander patterns, involving a widening of the agenda of logic. For, "What is to be done" amounts to re-thinking what logic is *about!*

What is the paradigmatic logical activity? In a recent talk about traditional Indian logic, I heard about what were considered the three basic ways of getting information. In modern post-somatic terms, suppose you want to know if beer is available on the beautiful *IITK* campus in Mumbai. You can either try to *deduce* this from the many leaflets handed out to you upon arrival. But, you can also go out, walk around the campus, and use your powers of *observation* to check for beer outlets. Finally, you can do neither of the preceding, but just *communicate* with an authority, asking a student whether there is beer around here. On a broad conception of logic, all three channels of information would be topics for theorizing, trying to fit them into one coherent picture, moving beyond the excessive attention to deductive mathematical proof. The latter is surely just one logical activity amongst many, and one which misses all more complex interactive features of language flow and interaction between reasoning agents. I would say nowadays that a social act like asking someone a question, or giving an answer, is just as much a paradigmatic logical activity as the individual act of drawing a conclusion from given premises.

Indeed, in the modern research literature, logic is about any process that transforms and transmits information: reasoning, computation, questioning, announcing, or learning. Many of the resulting new issues, I would also say, have to do with opening windows from logic and philosophy toward other disciplines, such as computer science, linguistics

– and these days also economics and cognitive science. Incidentally, this outward-looking stance is not opposed to traditional mathematical or philosophical logic. It may even provide a more convincing *raison d'être* for their achievements beyond the narrow conception of logic as a science of formal systems which I find barren and hard to defend as a reason for funding a discipline. In that sense, that journalist did strike a chord...

Here are some general issues that illustrate this broader view, without exhausting it.

General insights beyond formal systems My first illustration does not even extend the agenda, but just steps back a bit to look at what we already have. Logic in its formal systems mode leads to 'systems imprisonment' (van Benthem 1999), since its results are always relative to elaborate formal languages and axiom systems, and their scope may end just there. In fact, this whole-sale feature is one of the most alienating features of the field to non-logicians. But can we cast logical insights in a formalism-independent format, just as major laws of physics can be understood without buying into elaborate formal languages and axiom systems? For instance, much of logic is about a *balance* between the expressive power of formal languages and the complexity of performing natural tasks for them, such as model checking for truth, consistency maintenance, or valid inference. This is the thrust of many meta-theorems, including Gödel's and Tarski's celebrated result about the limitations of first-order logic. The 'Golden Rule' of logic says that gains in expressive power are lost in higher complexity. Are there deeper results in the background here, explaining what features of a logical system trigger and determine this behaviour? And what further insights from logic could be cast in a cultural form with broader impact? We seem to need a level of stating significant logical insights in between detailed system mongering and empty generalities which is not available right now. Instead, well-meaning contemporary logicians compile huge catalogues of results on families of formal systems, which often aggravate the problem, by removing any reasonable view of the whole.

Plurality and architecture My next theme also reflects current realities inside logic. Plurality of logical systems has been a hallmark of current research for a long time now, ever since Bolzano and Peirce, and on to the 'alternative logics' (an obsolete phrase), proposed for very different styles of reasoning by Brouwer, McCarthy, or Girard. The grand questions behind this would seem to be: what are the major varieties of reasoning, their criteria for validity, and their different formal properties? In particular, there has been an explosion of work in 'non-monotonic', 'linear', 'para-consistent', 'abductive', or 'default'

reasoning, and many other varieties of inference arising naturally for different reasoning tasks. Could there be one over-arching theory of reasoning behind all of this, with natural parameters which determine when we use one mode rather than another? Also, if we take this plurality seriously, a further concern arises. Real-life logical tasks are structured, and involve combinations of different languages, proof calculi, and semantic models. This structuring calls for combinations of logics, just as significant physical systems usually bring together different parts of physics. But despite some promising incipient literature, we still lack a general explanatory theory of the architecture of combined logics, and their properties as a function of the properties of the component logics plus the combination mechanism. There is no significant logical understanding yet of 'emergent properties' of combined architectures. Often, there is even a paradox. Combining information sources and processing mechanisms seems to do us good in real performance, whereas it tends to lead to combinatorial explosion in systems building. Are we still missing an essential ingredient in understanding the situation?

Information carriers and channels Most of logic is about language as a vehicle of meaning and inference. But over the past decade, other information carriers have come to the fore, such as diagrams, pictures, or images. Likewise, information need not be read off from paper: it also comes from observing cards, or light signals, or indeed, any type of event with some regular connection to other situations. What is the relationship between linguistic, graphic, and yet other information in reasoning, and how are the two to be integrated? Can standard logic, whose major paradigms of expressive power and computation (like formal languages and Turing machines) so far have been language-oriented, adapt to such broader notions of information? In principle, every physical system can carry information provided there is enough regularity in the environment. The 'channel theory' of Barwise & Seligman is an attempt, following Dretske's classic *Knowledge and the Flow of Information* to bring this into logic. But what is the underlying notion of information, and what are the implications for logic? The forthcoming *Handbook of the Philosophy of Information* (P. Adriaans & J. van Benthem, eds., to appear) tries to address some of these issues, but a unifying notion of information across qualitative logic and quantitative information theory still seems hard to find.

Dynamics, many agents, and interaction Logic has been mainly concerned with properties of eternal objects like propositions, or inferential relationships between these. But such objects are the results of activities, such as learning, updating one's information

state, revising a belief, asking a question, testing or challenging a given assertion, etc. This dynamics has become an object of logical study in itself, thanks to the pioneering work of Gärdenfors, Kamp and the Dutch School in semantics (cf. van Benthem 2003A, B). It can often be studied profitably in tandem with techniques from program analysis in computer science, due to pioneering authors like Pratt, Milner, or Abramsky. What would be a stable paradigm for the logical dynamics of reasoning and other cognitive processes, comparable in sweep and elegance to first-order logic or modal logic? Now, one typical feature of logical activities is that they usually involve more than one agent. Major logical skills are displayed in *social interaction* between different agents. Examples are asking, answering, telling, and upward from there: longer-term strategic behaviour in games of various kinds: argumentation, model building, planning. More ambitiously, groups can be logical actors, and this raises further issues of collective predication and collective action. This social aspect of logic has been penetrating into epistemic logic and some parts of computational logic, especially in the guise of *games*. There are many paradigms for this, ranging from Hintikka's game-theoretical semantics to game semantics for linear logic, and eventually: plain game theory. The general logic of interaction will presumably merge strands from concurrent computation to epistemic logic. But: what is it?

Time scales and probability A single inference step, or a question, is just one logical action. Conversation or games take longer stretches of time, but they still seem to fit the 'attention span' of standard logical theory. But what about the still longer term? In assessing information, we consider some agents more 'reliable' than others. But the expectations, or numerical probabilities, which we attach to that reliability is really a summary of long past experience over time. Likewise, we engage in long-term processes that may not even terminate at all, such as the Great Game of ongoing conversation and argumentation that binds a whole society together. These involve expectations about the future, and their revision as new observations are made. Part of this perspective fits very well with existing logical theory, especially, temporal logic of infinite streams of events as it has evolved at the interface of philosophy, computer science, and learning theory. But there is more to the encounter than mere juxtaposition when we bring in *probabilities*. Bolzano already listed statistical inference as a key logical concern, and so did Pierce. Carnap tried to unify statistical and logical perspectives on information in the 1950s. Through the 1990s, this encounter has intensified, as experience was gained with large-scale behaviour of automated proof systems over time. The discovery of emergent statistical properties of such systems is only starting, but that they exist is shown by the

Zero-One Law for predicate logic, discovered in the early 1970s – saying that in the long run, on finite models, first-order statements are either true or false with probability 1. Ironically, this happened just after Lindström seemed to have proved an end-of-history theorem characterizing first-order logic once and for all in terms of its classical qualitative properties. The logic-cum-probability trend links up with the rise of evolutionary game theory, where long-term repetition of simple interactions can lead to equilibrium explaining stable norms and other population behaviour. Integrating logic and probability has always been a marginal interest among logicians. In modern practice, it may become a central one.

These themes are a fair reflection of trends in modern logic, it seems to me, provided one views things from a higher altitude than established orthodoxy, or specialized research communities. Admittedly they are still a far cry from what one finds in standard textbooks or texts on philosophy of logic' – but I think they raise the essential general issues.

4 Discussion: Where Should Logic Go?

My view of logic suggests that we are on the threshold of a new agenda for the discipline as a study of reasoning, information and communication. This may be seen as a return to broader pre-Fregean ambitions, with the mathematical tools provided by the 'contraction phase' of foundational research. I would hope that this process will again produce major fundamental insights, comparable to those of the Golden 1930s. TIME 2000 listed Gödel, Turing, and Wittgenstein among the 20 leading intellectuals of the 20th century: surely not a bad score for our little field! Let's hope that TIME 2100 has a few other names to add...

A Grand Program? But can a movement work without a Goal? Modern logic started with Grand Programs in the foundations of mathematics or the sciences generally. These were largely refuted, and in their downfall, their fall-out enriched whole areas of philosophy and the sciences. I feel that, one century later, we should move on, and recognize that, by now, we are really pursuing more ambitious goals, with logic becoming the study of all natural mechanisms that transform information, along the lines that I have sketched. Still, I have no refutable program to offer – that aims high, and then stumbles. Hilbert promised us the provable security of mathematics, with the lofty spires of Cantor's Paradise in the background. Perhaps I can promise the Ultimate Rationality of Mankind in its reasoning and informational endeavors? In any case, it would be a rationality with a much richer repertoire than just proof, including mistakes and revisions, questions and debates, and much, much more. That is the reality of life after the Fall, now that we have eaten from the Tree of Knowledge – and its dynamics is much more interesting than any static Paradise.

Once again: method versus content One question which I find it hard to answer is, again, whether my line of thinking amounts to a view where logic has a subject of its own. All the topics that I have discussed also belong to the province of mathematics, linguistics, computer science, psychology, and cognitive science. Logicians have something to offer, but they are not the only player in the field. But is not there a standard response here? Could it be, perhaps, that logicians are the guardians of *correct* reasoning, *genuine* communication, and *ideal* information flow? I would not want to think about divisions of labor here in quite the usual way. Discussions of 'normative' versus 'descriptive' views of logic have become predictable and boring.

The Triangle: theory, reality, and new design The issue as I see it is rather the surprising *interaction* between all these different perspectives. Phenomena like reasoning or information flow suggest a natural Triangle of perspectives:

(somewhat normative) *theory*, *empirical reality*, but also *virtual reality*,
 the construction of *new systems and new forms of behaviour*
 by the interplay of the former two.

Accordingly, theoretical logic, empirical psychology, and constructionist computer science form a natural Triangle of disciplines, each approaching the topics on my agenda with a different thrust. This is an exciting world to live in – and an ambitious one, as it is not confined to analysing already existing behaviour, but also has the potential of designing *new habits*. As Marx famously said,

"Philosophers so far have merely interpreted the World.
 But now the time has come to change it."

If we triangulate like this, the value of the logical stance among its peers is not that it has the last word on anything, but rather that it enhances our view on information, computation, and cognition, and adds a dimension, both in analysis and design. Thus, logic is to be judged, not just on its ability to bring to light laws of thought or rationality, but on its potential for generating new rational practices with new rules and perhaps new agents. Logic programming, argumentation procedures, logical games, and many other new phenomena show that this activist mode is viable and worthwhile.

5 Back to Philosophy

It will be clear that thinking about the future of modern logic released a lot of positive energy in this author. And much of this is even genuine. When I was still a director of the Amsterdam Institute of Logic, Language and Computation, optimism was of course a simple moral duty – and I would often quote the Russian censor Count Benckendorff to my colleagues, who once said that the rules of safe writing were simple:

"Russia's past was glorious, Russia's present is magnificent,
and Russia's future is beyond the wildest imagination".

Now that I am no longer at the helm, I still believe most of what I wrote back then. Moreover, I believe that my agenda for logic also represents significant philosophical issues about the workings of information and cognition.. Much the same set of concerns, I would claim, affects the philosophy of language, epistemology, and philosophy of science today – and even philosophy at large. And my views about the proper attitude in this broader world also apply much more broadly. Philosophy is a stance which cannot work without intensive live contacts with surrounding disciplines. And its virtues should be judged in several ways: good philosophy provides abstract perspectives fed by reality, but it can and should also influence and transform our lives in new and surprising ways. If we do that, there is no need to escape: Lake Michigan will be right alongside our hotel.

What is to be Done? It is time to close the circle of my essay. What about Lenin's title in the light of our Triangle? When he analyzed the situation of the Socialist movement in 1902, his main conclusion was that there was nothing wrong with the basic theory of Marxism, while the empirical conditions of the proletariat were also more or less as expected. But in his view, a stagnation had occurred which put a ceiling on what new things could be achieved. Moving toward the third vertex of the above Triangle, he advocated a new design. True revolutionary progress now required a new style of ideology and organization, with Lenin's communist party as the vanguard of salvation. Perhaps, in the same vein, the only thing that needs to be done in logic, and likewise in philosophy, is a matter of organization, rather than substance. One has to make sure that the change-minded innovative people continue to meet and exchange ideas. But that, I guess, is precisely what Ermanno Bencivenga's idea with this volume was all about.

6 References

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