INSTITUTE FOR LOGIC,
LANGUAGE AND COMPUTATION

Logic in Action 1998

AN NWO SPINOZA AWARD PROJECT

NWO

UNIVERSITEIT VAN AMSTERDAM

Logic in Action

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Leaflet and report, 1998

Amsterdam, April 1999

Institute for Logic,
Language and Computation

Universiteit van Amsterdam

Plantage Muidergracht 24
1018 TV Amsterdam
Phone: +31 20 525 6051
Fax: +31 20 525 5206
E-mail: spinoza@wins.uva.nl
http://www.illc.uva.nl

Design: Crasborn Grafisch Ontwerpers BNO, Valkenburg a.d. Geul
Photography: O.H. Rockener, Amsterdam
Editing: I. van Loon, Y. Venema

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In October 1996 Johan van Benthem, professor of mathematical logic at the Universiteit van Amsterdam, was awarded one of the Spinoza prizes by the National Dutch Organization for Research (NWO). The award consists of an amount of two million guilders, meant as financial support for future research.

Logic in Action is an initiative of the Spinoza recipient and his research group members made possible by this grant.

Its general aims are the formal study of information flow and the promotion of logic as an interdisciplinary focus for the information sciences.

A snapshot of the Spinoza ceremony, October 10, 1996, De Ronde Lutherse Kerk, Amsterdam; Photo: © J.A. Kriele

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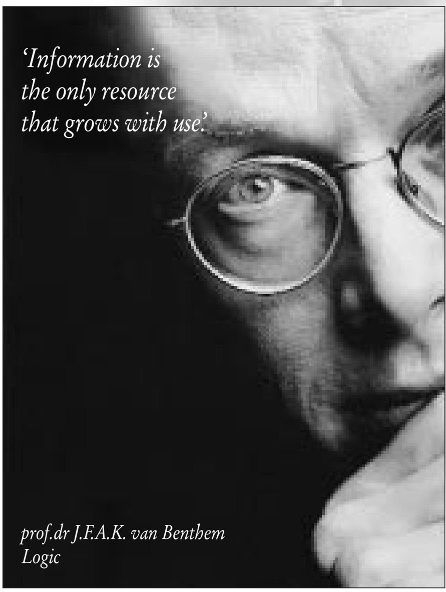
Preface

MOVES THAT MAKE INFORMATION FLOW

Information flow is present in all human activities. It is not just that any enquiring mind wishes to learn facts per se, from the truth about Fermat's Last Conjecture to Claudia Schiffer's phone number. Information is tied up with all other aspects of our behavior, determining guilt or innocence ('did they know...?'), hopes and fears ('what did the doctor find out...?'). There are lots of ways of being scientific about this phenomenon. For a long time, telematics engineers have measured information in the bulk, the number of physical bits that get through a communications channel. No meaning is involved here, just code. Large numbers are also conspicuous in the recent trend of measuring long-term statistics for opinion change in large crowds, where small transitions from repetitive encounters (say, gossip) have greater effects in the long run than the initial truth of the matter. Our Spinoza project 'Logic in Action' sits in the middle between these physical and sociological levels. We are interested in the informational content of individual speech acts, communicating meaningful information. Users of natural language are all experts in achieving this transfer. What is much harder is to understand how it works *precisely!*



Dynamic logic as developed at Amsterdam's ILLC is a paradigm for representing meaningful information, and describing ways in which it may be updated. Roughly speaking, one's current information is correlated with a space of options that we still see for the true state of affairs, which may be represented by various state-models from logic. Communicative updates change these state-models - usually reducing uncertainty, and the resulting systems can be studied for their mathematical and computational properties. But let's not talk theory on this opening page! A most amazing thing is the subtlety of information transfer that humans accomplish. Communicative conventions in natural languages are fixed. We have to live with them, and cannot change them at will. But on top of this, to make life a little harder than just 'straight talk', we invent *games*. Moves in games allow players to present or hide information, according to certain rules. And what information gets passed in this way is often easy to 'sense', but hard to formulate exactly. Take the simplest episode that might occur in any game. The two of us have each just drawn a closed envelope. It is common knowledge between us that one envelope holds an invitation to a lecture on Fermat, the other a dinner date with Claudia Schiffer. Clearly, we are both ignorant of the fate in store for us. Now I open my envelope, and read the contents, but without showing them to you. Yours remains closed. Which information has passed *exactly* because of my action? I certainly know now which fate is in store for me. You have also learnt something, viz. *that* I know - though not *what* I know. And likewise, I did not just learn what is in my envelope. I also learnt something about you, viz. that you know that I know. The latter fact has even become common knowledge between us. And all these 'cognitive overtones' can be relevant to further communication. Dear reader, try to formulate *exactly which information* has been passed in this one simple move of opening my envelope, which a child can understand! Then try to find a general principle behind this. You may find it much harder than you'd think. And you will understand why logical analysis of information flow is a challenge.

Once we have answers to these questions for significant games, we can go into systems-building and theorem-proving mode again, or think of computational methods for playing. The integration of these various ingredients, too, is present in the Spinoza project, as you will see in the coming pages. But let us also reflect on a more general nicety of the situation. Unlike natural language, games are open-ended. New games, with new conventions, appear all the time. If we wish to study the effect of logical theories of information flow, we might even invent new ones ourselves, and (why not?) market them, and observe human responses to them. Thus, games form a cognitive laboratory, provided for free by Nature, which challenges logicians, which gives them the possibility of controlled experimentation, and which is fun at the same time.

Chapter 1 The Spinoza program of NWO

The following is an excerpt from an NWO brochure

The NWO Spinoza programme was launched by the Netherlands Organization for Scientific Research as a complement to promoting science in research schools. The programme is the most prestigious one in Dutch science. Its aim is the promotion of excellent research by identifying and awarding a very limited number of scientists (circa 3 per year) with a large grant. Spinoza laureates are scholars and scientists who are internationally recognized and whose contributions have been of paramount importance to their scientific field of research. They have an impressive list of high-quality publications, an excellent citation-index and are stimulating leaders towards their numerous Ph.D. students. Their outstanding abilities have been recognized both nationally and internationally by means of awards, prizes, invitations, etcetera.

Candidates are selected by a central committee, on the recommendation of invited leading figures from the Dutch academic community. The Spinoza programme corresponds to NWO's philosophy that the determining factor for 'top research' (which will usually take place in a research school) is in the first instance a person with vision and not an institution.

The awards honour past performance, and are also meant as a stimulus for future innovative research. Spinoza laureates are entirely free in spending their award on research of their choice. The following scientists have been honoured by a Spinoza prize so far:

1995
- G. 't Hooft (theoretical physics, Utrecht University)
- E.P.J. van den Heuvel (astronomy, Universiteit van Amsterdam)
- F.G. Grosveld (cell biology, Erasmus University Rotterdam)
- F.P. van Oostrom (Dutch literature, Leiden University)

1996
- J.F.A.K. van Benthem (mathematical logic, Universiteit van Amsterdam)
- P. Nijkamp (regional economics and economical geography, Free University Amsterdam)
- G.A. Sawatzky (material physics, Groningen University)

1997
- F.H.H. Kortlandt (Balto-Slavic linguistics, Leiden University)
- H.M. Piñedo (medical oncology, Free University Amsterdam)
- R.A. van Santen (inorganic chemistry and catalysis, Technical University Eindhoven)

1998
- J.H.J. Hoeijmakers (molecular genetics, Erasmus University Rotterdam).
- H.W. Lenstra (fundamental and applied mathematics, Leiden University)
- P.C. Muysken (general linguistics, especially Ibero-American languages, Leiden University)

Chapter 2 Logic in Action

Aim

As information technology is transforming our society, fundamental questions concerning the structure and dynamics of information and cognition are also transforming academic research and education. This trend affects disciplines ranging from linguistics to mathematics, and from computer science to psychology. These interactions are generating a remarkable convergence of techniques and ideas, pointing towards a new natural grouping of what may be called information sciences.

In many of these developments, one sees influences from Logic, serving as a catalyst. The historical focus of this discipline has been the domain-independent structure of reasoning and meaning. But through the past decades logic has evolved naturally into a more general exact study of all sorts of structures and processes that drive information flow. Logical semantics provides representations for meaningful information, logical proof theories provide dynamic mechanisms for processing information, and these insights can serve both theoretical understanding and practical computational implementation. In a slogan, logic might become the ‘calculus of information science'. This challenge defines the scientific theme of the Spinoza project 'Logic in Action': namely, *the logical structure, modification and transfer of information.* Naturally, one has to make choices in this vast area, and our specific flavor will be described below.

The project's general ambition is threefold. Its fundamental component consists of research in the trade-mark tradition of logic, leading to the design and meta-analysis of formal models of information and its flow. But there is also a more computational dimension to the project in which the group's ideas are put to work in actually implemented systems. And finally, special attention is devoted to the use of our ideas in communicative situations, in particular, by innovative teaching.

Themes and style

Most activities of 'Logic in Action' revolve around three themes. These illustrate the interactions between logic, linguistics, mathematics, and computer science that are characteristic for the ILLC research environment. This reflects a long-standing tradition of information-oriented logic, which has brought Amsterdam to a leading position in the field of intuitionistic and modal logic.

Dynamic models for information and communication
One of the essential properties of information is that it can be transferred or communicated from one agent to another. Thus, a central aim of the Spinoza project is to develop and study formal models of such communication processes. It is clear that even the simplest forms of communication intertwine such diverse notions as knowledge, physical action and information change, and that a multi-agent perspective is essential. Many interesting research problems arise from finding out how such features interact, in rich epistemic action logics that combine individual information states with collective ones. An example on the empirical side is our analysis of linguistic 'presuppositions' as side conditions for successful information processing.

BLIKSEM!

The theorem prover Bliksem is one the main computational logic tools that have been developed in the Logic in Action project. In the competition at the fifteenth international conference on Automated Deduction (CADE, 1998) in Lindau, Germany, Bliksem did very well, coming out second in most categories, in particular in the categories of first order theorem proving and clausal logic. Hans de Nivelle about Bliksem:

Bliksem is a first order resolution based theorem prover, designed to be theoretically up to date, technically efficient, and application directed. In order to tune Bliksem towards applications we have made efforts to make the syntax as readable as possible, and to avoid all constructions that might make it non-portable. In fact, we have not yet encountered a platform on which Bliksem cannot be installed! Its technical efficiency is partly based on a choice for suitable datastructures; our choice for the representation of logical formulas for instance was based on experiments with several different ones. For those who are interested in some technical details, Bliksem uses efficient strategies for equality reasoning, based on the superposition calculus. For non-equality problems it has non-liftable orders and semantic resolution. Bliksem also has special strategies for certain fragments of first order logic; in fact, it provides decision procedures for the guarded fragment (a Spinoza effort) and the two variable fragment.

In the future, we want to apply Bliksem in interactive verification, and to enhance its compatibility with interactive verifiers. Another goal is to improve the applicability of Bliksem to non-standard logics. For instance, although we have reasonable success in working with modal formulas, we also see opportunities for substantial improvement. Finally, Bliksem is currently used for the resolving of ambiguities in natural language. For this kind of applications it is very important that Bliksem terminates in the case that there exists no proof. This involves some fine-tuning of the decision procedures.

BLIKSEM!

Correspondences between natural and programming languages

Modern information technology has made the borderline between natural and computer languages increasingly fuzzy. At the same time, fundamental research has revealed deep parallels between these kinds of languages. A prime example is the 'dynamic turn' in the semantics of natural language, in which linguistic utterances serve as instructions for updating the information state of hearers or readers. This paradigm was directly inspired by theoretical work on the meaning of programming languages. More concrete parallels abound. In particular, we are also exploring a converse tack, developing computer systems that program with ideas from dynamic semantics - and eventually even with sentences from natural language, or fragments thereof.

Reasoning with pluriform information

Logicians are traditionally working with formal languages that have a simple syntax and a perspicuous semantics. This suffices for an idealized analysis of pure scientific reasoning. But actual information comes in many different ways, including non-symbolic forms like pictures or more general signs. Moreover, in many situations one must draw conclusions on the basis of information that is ambiguous or underspecified. The precise handling of this phenomenon is a challenge, beset with combinatorial explosions. We are developing new logical representations that can deal with ambiguous and pluriform information.

Communication, language parallels, and pluriform information are key interests in the Spinoza project. As for our style of working on such topics, the following points are noteworthy.

Modal logic in context

The Amsterdam tradition in modal logic provides the backdrop to much of the formal modeling in the project, both of information structures and processes. Modal logic is pleasantly robust in its balance between expressive power and computational simplicity, while retaining a nice metalogic. Hence a large part of the group's research is performed within a framework of modal logic and related formalisms like dynamic logic, or the guarded fragment of the predicate calculus. One characteristic of our approach is the development of new systems 'in tandem' between modal logics and more classical languages, with a variety of tools from model theory, universal algebra, and other technical sources.

Computational Logic
There is also a more practical side running through our whole project. We take the project's name quite literally, in putting the group's abstract ideas to work. One particular effort is the construction of effective theorem provers and model checkers for formalisms like modal logic or the guarded fragment, thus making the nice computational behavior of such systems very concrete. Another is the development of tools for reasoning about complex domains with pluriform and underspecified information. All this material is being made publicly available on the Internet.

Logic education and dissemination
Since logic has an important part to play in the information sciences, we believe that it deserves a place in broader curricula, and in the minds of the general educated public. While this is a task for the logic community at large, we are undertaking several pilot actions of this kind, including university course innovation, electronic long-distance teaching, and research on interactive documents, both using and spreading our ideas on information flow.

Structure

The members of the Spinoza project form three groups. 'Logic in Communication' sits at the interdisciplinary interface between humanities and exact sciences, thus aiming at further 'alpha-beta-ization' of the university, 'Computational Logic' is a pilot project for making computational concerns and facilities an essential part of our research efforts, while 'Dissemination of Logic' is a kernel project for translating our research efforts into insights and tools for a larger community. It should be noted that this division does not compartmentalize activities, since many group members take an active interest in topics 'officially' falling under some other project. In particular, computational and didactic interests run across the board. Besides these three project groups, the overall project has a 'free space', devoted to stimulating general events and encouraging new individual initiatives. Part of its resources are allocated to regular items, such as the Spinoza lecture at the European Summer School on Logic, Language and Information, or the annual European prize for the best dissertation in pure and applied logic. But for another part we will continue to look for new opportunities for broader communication. 'The unknown' deserves a hearing!

Interactions

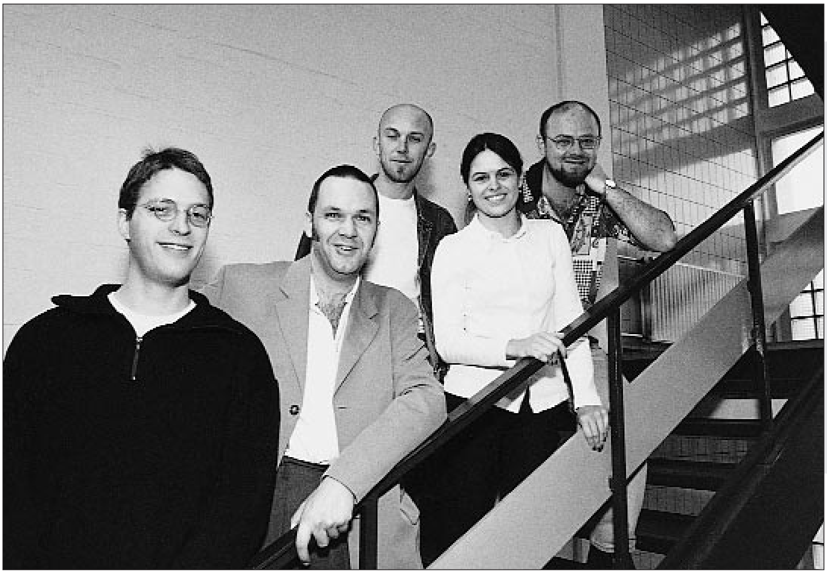
First of all, this Spinoza project could not function without its embedding in a stimulating academic environment, provided by ILLC, OzsL, and FoLLI, whose description and electronic coordinates can be found on p. 33-36. Equally important is the continued financial and logistic support from the faculties of Sciences and Humanities at the University of Amsterdam. But over and above organisational structures and electronic data, science still depends on a network of personal contacts. 'Logic in Action' collaborates actively with several research groups abroad. These include Aachen, Edinburgh, Helsinki, London, Saarbrücken, and Stanford - where Johan van Benthem spends his spring quarters as a visiting professor at ILLC's sister institute, the Center for the Study of Language and Information. Finally, part of the Spinoza resources are spent on individual visitors, as well as workshops and conferences that create new scientific alliances.

Chapter 3 LOGICIANS IN ACTION 1998

The Spinoza activities in 1998 are documented by the following reports. We first mention some of the research activities of the sub groups, then pay attention to logic dissemnination activities of the project, and finally list the most important events that have been organized by group members and guest visits that have taken place.

Logic in Communication

The 'Logic in Communication'-project is concerned with the formal study of communication and information flow. The aim is to synchronize the focus of two research trends which are firmly rooted in Amsterdam and which have proved to be both very successful empirically speaking and very inspiring in the context of the international research community. The modal logic tradition provides a scientifically sound basis for the study of formal and logical properties of information, information gain, information loss, and directed information exchange. The dynamic semantic paradigm feeds the logical one with conceptual, computational and even paradoxical issues which arise in the study of natural language interpretation and reasoning.



FROM LEFT TO RIGHT: JELLE GERBRANDY, YDE VENEMA (PROJECT LEADER), MAARTEN MARX, ANNETTE BLEEKER, ALEXANDRU BALTAG. NOT ON PICTURE: PAUL DEKKER (PROJECT LEADER)

In 1998 the project really got of the ground when the contribution of three coming talents was secured and that of the principal investigators was guaranteed. From that moment onwards, the project had a safe home for (scientific) action. Collaborative research approached the topic of communication in a number of different ways, of which we mention two prominent developments.

One theme is concerned with the startling question of 'Who knows what?' in distributed information environments. In most formal and natural life applications, we find some agents who know something, some agents who exchange some information to some other agents, and some agents who monitor these exchanges. In these environments the question is relevant - theoretically, but also sociologically and economically -, who can be supposed to know what, or who can be supposed to know exactly what other agents know. Reasoning about these questions is not only conceptually but also computationally extremely confusing and complex. Suitable extensions of the modal logic and the dynamic semantic paradigms have given us a handle to approach the questions from a systematic perspective. Some foundational issues have to be addressed here: for instance, it seems that a foundation in ordinary set theory is not the most adequate for dealing with the concept of information change from a multi-agent perspective. Rather, a co-algebraic perspective is required which arose from work on an alternative, non-wellfounded set theory.

The second peg we have been hanging our coats on is that of game theory. The theory of games provides us a framework that is on the one hand rich enough to be interesting for a general theory of communication, but on the other hand restrictive enough to allow for a rigid and elegant mathematical analysis. This is because it comes with fairly precise notions of agency and communication. Game theory is also attractive because game theory has such a wide range of applications, running from economic theory to the semantics of formal and natural languages.

The game-theoretical paradigm opens up a new approach to information and information exchange. As an example, take the so-called 'games of imperfect information' in which agents have to make moves without exactly knowing where they are. Such a setting really is a characteristic property of agents in any natural environment. Still, even in laboratory environments it is unclear what this amounts to from an information-theoretic perspective. Our interest is partly to test the feasibility of the game-theoretical paradigm as a formal tool for approaching these questions, while on the other hand the game model lends itself for an analysis in terms of modal logic. A second and more theoretical

A Visit by Mints

A Visit by Mints

Grigori Mints, professor of philosophy at Stanford University, is a logician working with proof-theoretical methods, with applications to classical and inuitionistic logics of first and higher order, as well as to modal logics. In March 1998 he visited ILLC for a period of three weeks.

'The Institute for Logic, Language and Computation in Amsterdam was exactly the right environment for concentrating on the topic of 'interpolation for non-classical logics', which needs more systematic attention in my view. I spent a lot of time working with ILLC graduate students, both by teaching a master class on interpolation theorems, and by discussing their work and advising them on possible new approaches. At the risk of being too technical, I state one specific result 'made in Amsterdam', viz. an interpolation theorem for intuitionistic predicate logic.

Craig's original interpolation result from the 50s says that derivability of an implication X,X' —> Y' implies the existence of a transmission link called an 'interpolant'. The latter is a formula I in the common language of X and X' —> Y' for which both X —> I and I,X' —> Y' are derivable. Now, for classical logic this interpolation property extends to sequents X,X'—>Y,Y' with multiple conclusions. But for intuitionistic logic, counterexamples are known, so that the result seems less general. During our stay, however, we found a way around this difficulty, finding interpolants for a multiple conclusion version of intuitionistic propositional logic which are systems of sequents rather than one formula. For intuitionistic predicate logic, a more sophisticated version is available, too.

Besides this research, and the ample time spent with students, I rushed from conference to seminar to workshop, presenting even a talk on 'industrial applications of logic'. My contacts and discussions with ILLC staff were most valuable, ranging over subjects like Skolemization and normalization techniques, proof strategies in automated deduction, and 'manageable fragments' of classical and non-classical logics. In short, my Spinoza visit was a great opportunity to work at a stimulating environment offering interactions with researchers of different generations and backgrounds.'

example is formed by the game-theoretical analysis of the formal semantics of logic itself. Consider Hintikka's games for predicate logic, where players choose values for variables in the course of a game. There has been a lively discussion whether such a semantics can be rendered compositional, even in the case of imperfect information. There are interesting and direct parallels here with the discussion on the compositionality of dynamic semantics, parallels that we would like to understand more deeply.

Also in other fields we want to proceed on the road that we have taken in 1998; for instance, we plan to widen the range of our work on formalizations of communication processes, by taking more aspects of communication into account such as encrypted message passing. On a more mathematical level, we think that the connection between modal logic and co-algebra's deserves further investigation. On a more applied level we will pursue the use of games and connectionist methods in the area of interpretation.

Computational Logic

The main mission of the Computational Logic project is to make computational concerns and facilities an essential part of research efforts at ILLC by turning sophisticated abstract theories into working systems. The project is a family of concentrated, small scale research efforts aimed at 'making

From left to right: Hans de Nivelle, Carlos Areces, Christof Monz, Maarten de Rijke (project leader) theories work' in each of the Institute's three main lines of research, logic, language, and information. The project tries to achieve this general goal by building on existing research traditions within ILLC and by a strong focus on modularity, proof calculi, and computational experimentation.

While 1997 witnessed the start-up phase of the project, 1998 really saw it take off, with the arrival of the project leader and other project members. Regular group meetings got under way, and a variety of events was organized, ranging from intensive courses on computational logic tools to an international workshop on modularity in logic and computation.

The group's work is organized along three interrelated lines: Computing with Logic, Computing with Language, and Computing with Information. Our first full year of activity was mainly devoted to starting up the first two lines.

In 'Computing with Logic', the emphasis is on proof calculi and decision methods for restricted description languages, and on the expressive power of such languages. This work builds on the strong ILLC tradition in modal logic, but it adds a clear computational slant, as is witnessed, for example, by the development of theorem proving tools and resolution-based calculi. What is a restricted description language? While we do not offer a general definition, a useful working definition runs as follows: a restricted description logic has limited quantificational force so as to ensure a low complexity of its basic reasoning tasks. Obviously, for many modeling or specification purposes such restricted languages will indeed be... too restricted. Now, instead of blindly extending the expressive power of such languages, the strategy we propose is that one should exploit combinations of small, dedicated languages and tools, and break down complex modeling tasks into smaller ones that can be dealt with by dedicated components. The attraction of such modular, re-usable logic tools seems obvious as the need to reason about the flow of information in a structured way is important if complex systems are to be properly understood, designed and maintained. While the theoretical aspects of decomposing complex reasoning tasks into simpler, more restricted ones is reasonably well understood, we are only at a very early stage in the development of practical implementation methods. The area is full of interesting and non-trivial challenges, and our ongoing work here tackles these by developing new, fully explicit proof formats, and by exploring distributed, Internet-based implementations of tools.

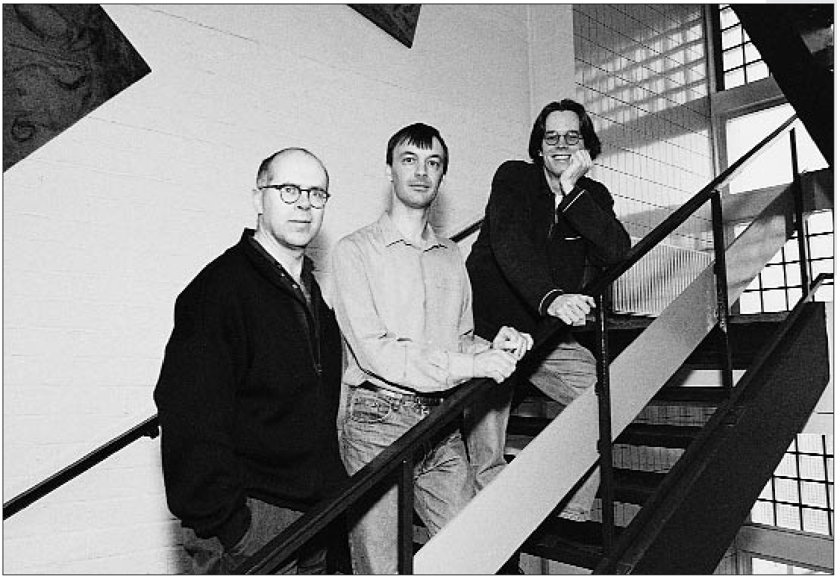
Our work on the second research line, 'Computing with Language', is centered around reasoning with ambiguous expressions, and aimed at building bridges with another of ILLC's strong research traditions, viz. dynamic logic. The kinds of ambiguity we are trying to handle are pronoun ambiguity ('Fat Freddy saw his neighbor. He ran off'), quantifier ambiguity ('Every logician studies a calculus'), and their interaction. We are complementing existing semantic representation theories developed at the ILLC with dedicated proof procedures. As in 'Computing with Logic', modularity is one of the key principles here. Ambiguous expressions tend to blow up the complexity of (refutation) proofs and the number of choice points in such proofs dramatically, and we are coping with this by postponing disambiguation as much as possible and by using various dedicated modules to prune the search space.

Our plans for 1999 include a further strengthening of the above two lines, with a stronger emphasis on performance and on practical uses of the tools that we are developing. Specifically, component-based approaches will be used for the development and analysis of computational logic tools and tasks, and we are in the process of doing so in the areas of image retrieval and feature interaction in telecommunication systems. Moreover, our third line of research, 'Computing with Information', will really get under way. Here, we aim to put logic and natural language processing tools together to help us understand as well as process and manipulate information. In particular, 1999 will see the start of a project on information retrieval, and a project on structuring electronic information.

While the above goals and plans aim to explore the project's research goals, we will continue and extend our efforts to increase the accessibility and usability of computational tools in each of the key areas of the ILLC, by staging short courses and workshops, and by making our new software available through standard web browsers.

Dissemination of Logic

Within the Spinoza project the main task of the 'Dissemination of Logic' subgroup is to contribute to an informed, critical understanding of the information era in the minds of people getting their education at the turn of the twentieth century. On dissemination activities proper we will report later on; here we mention the key research theme that naturally came up in 1998.



From left to right:
Jan van Eijck
(project leader),
Hans de Nivelle,
Marc Pauly

An important 'Logic in Action' topic during the past year was reasoning with a variety of dynamic logics based on first order logic. As it turns out, dynamic versions of predicate logic put a new task on the logical agenda. The following is an example of a kind of natural reasoning that can be tackled only by a dynamic account of the way pronouns relate to their antecedents.

If a man owns a house, then he owns a garden
Suppose there is a man who owns a house
____
Then he owns a garden.

The pronoun 'he' in the conclusion of this argument is linked to an antecedent 'a man' in the second premiss. Also, the first premiss has an internal link of a pronoun 'he' to an antecedent 'a man'.

The extended task of logic is to work out rule systems that account for sound reasoning patterns with anaphora (that is, links from pronouns to antecedents) that reach between premisses and conclusions.

A calculus for a dynamic anaphora logic is a rule system for a logic that can handle examples such as the one above. Such systems involve a considerable

UPON ENTERING THE CLASSROOM WITHOUT HAVING TO COMB YOUR HAIR

Paul Dekker, David Beaver and Willem Groeneveld taught an Internet course on dynamic semantics. A personal impression by Paul Dekker, project leader of Logic in Communication.

GEOGRAPHICAL DISTRIBUTION OF THE PARTICIPANTS

At the first day of FoLLI's Summer School in Saarbrücken I was facing an audience of some seventy students. Fifteen of these we had taught a course not long before. Looking at the faces, I realized that the students with whom we had gotten so familiar had to be found among the people whose faces I did not *recognize. A case of inverse recognition? No, the result of teaching a course over the internet.*

We were just about to start the second part of a course on dynamic semantics. The introductory part of this course had been given for a restricted audience over the internet. In this introductory part, all course material had been made electronically available, but the web also served as the locus of direct exchange. We had a virtual office there and a virtual classroom, and both of them accommodated intense and sophisticated discussions.

Students from the U.S. West Coast up to Japan entered our world wide class every Wednesday to get to work. This was exciting. Differences in attitude, culture and local time aside (the class started at 08.00 U.S. West Coast local time and ended two hours later at 02.00 the next day in Japan), discussions were vivid, rich, and parallel.

Distance education is a prominent vehicle for distributing local expertise and reach academically isolated regions and our overal impression is that distance learning is here with us to stay. The most prominent deficit was felt to be the absence of visual clues. At the summerschool I realized my virtual homunculi students were really there, but I simply did not know which body they ran.

modification of standard rule systems, say for predicate logic, because they lack the property of monotonicity. If you add a new premiss to the premiss list, you run the risk of destroying the 'anaphoric pattern' of the argument, so you may no longer be able to derive conclusions that were derivable before. A dynamic anaphora logic counterpart to the monotonicity rule that allows extension of the list of premisses will therefore have to impose precise conditions that rule out a disruption of the variable binding pattern. Sound and complete calculi for dynamic anaphora logics were found by Jan van Eijck. These calculi are all related to a calculus for dynamic reasoning without variables.

There is a natural link between dynamic logic and programming, another area where various logical perspectives meet and where bridges can be built. Starting out from an interest in predicate transformer semantics for imperative programming, Marc Pauly got involved in the semantics for game logic, a modification of propositional dynamic logic intended for reasoning about games. As propositional dynamic logic was first invented to reason about indeterministic imperative programs, the study of game logic constitutes a link between programming semantics and game analysis. Also in this connection, tools were developed for the graphical display of evaluation games for dynamic logic formulas in Kripke models.

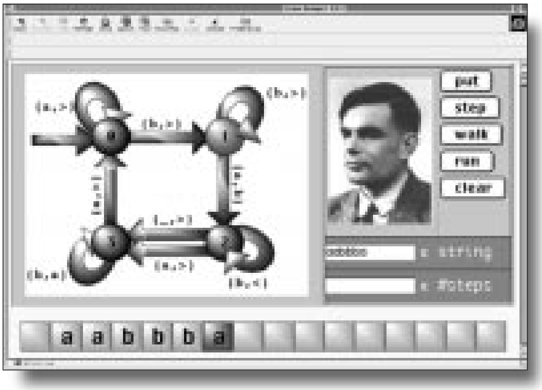
Dynamic variations on predicate logic turn out relevant not only for natural language and natural logic (as close as possible to natural reasoning), but also for programming. If one gives the formulas of first order predicate logic a dynamic interpretation one looks at formulas as actions. A disjunction 'A or B' becomes a choice between A and B, a conjunction 'A and B' a sequence of two actions: first A, next B, and so on. This action view of logic suggests an execution process. Still, as they stand, formulas of 'dynamic' predicate logic is not suited for execution on a computer. The problem is that the dynamic reading of an existential quantification 'some x' has become an invitation to pick an arbitrary new element from the domain of discourse. If one computes over, say, the natural numbers, this instruction imposes a choice from an infinite number of possibilities, and this is computationally not feasible. This can be remedied by splitting up the quantifier action for 'some x' between (1) forgetting the old value of x, and (2) picking a suitable new value. Part (1) of the quantifier action is performed immediately, while part (2) of the task is relegated to an appropriate identity statement further on in which variable x occurs. This trick leads to a genuine computational reinterpretation of dynamic predicate logic, and it is the basis of the programming language Dynamo that is currently under development in Amsterdam, as part of the Spinoza research effort. Dynamo programming creates a link between two research traditions

that are already strong in Amsterdam: dynamic logic and computational logic. See *www.cwi.nl/~jve/dynamo* for further information.
It is to be expected that further work on this will strengthen the interaction between previously separate schools of thought within ILLC.

Logic education

Innovation of logic education is taken very seriously throughout our Spinoza project, as is witnessed by the following pilot actions which were undertaken in 1998:

Computer-supported Logic Courses
The internet provides new possibilities for teaching logic. As with mathematics in general, learning logic requires a great deal of illustration, imagination and private training. These requirements often seem to be in conflict with the need of exactness of definitions, theorems and proofs as found in many standard textbooks.



New web-applications, such as Java applets and Javascripts, have made it possible to contribute to the visualization of mathematics, and logic in particular, which can be used easily in addition to textbooks. The Logic in Action group initiated the use of such techniques in several elementary logic courses. Simple calculators and animations have been implemented to illustrate logical theory such as propositional, predicate, dynamic and modal logic and elementary models of computation, which the student can use over the net for private training and experiencing the theory that they acquire from the courses and texts. A series of these web-applications can be found at *http://turing.wins.uva.nl/~jaspars/animations/*

Internet Course
The reality of the Internet is becoming less and less virtual, and 'Logic in Action' has contributed to this: with a world wide academic course 'Dynamic Semantics', David Beaver (Stanford) and Paul Dekker (Amsterdam) and Willem Groeneveld (Utrecht) were able to overcome geographic and temporal separation from each other and from their students. A more personal account of this course can be found on page 24.

Logic Dissemination Day

On June 5, 1998, logic education innovators from throughout the Netherlands gathered for an exchange of views and experiences. It was striking to see how much is going on in the way of integrating electronic education tools or with traditional courseware. As it turns out, training in elementary mathematical skills is an important ingredient in almost every introductory logic curriculum in the Netherlands. Experience with logic education tools such as 'Tarski's world' and various teaching aids for training theorem proving skills are mixed: the real hurdle is learning to use formal tools and methods, or even, learning to appreciate the need for disciplined formal thinking. To teach the use of logic as a meta-tool for studying the process of formalization itself seems to be a real challenge, in particular to students who lack mathematical maturity.

Modal Logic Book

Modal logics are paramount in the modeling of information oriented phenomena, and despite the enormous variety in appearance, on a technical level different modal logics have many things in common. Patrick Blackburn (Saarbrücken), Maarten de Rijke and Yde Venema are working on a Modal Logic text book that takes this 'unity in diversity' perspective as a starting point. A version of this book is available on the Internet at address
http://turing.wins.uva.nl/~mdr/Publications/modal-logic.html

Course on Isabelle

Interactive theorem provers assist users in verifying logics and proofs, and advanced provers have proved their mettle in enabling users to verify fairly complex models of computational systems. In this practical course by Sara Kalvala, attendees had the chance to learn how to use Isabelle, a proof system which can be used both as a logical framework (allowing users to model new logical systems) and a powerful verification tool.
http://turing.wins.uva.nl/~mdr/ACLG/Provers/Isabelle/isabelle.html

Introducing logic computationally

Kees Doets and Jan van Eijck tried out a draft version of their textbook on 'Logic, Representations and Proofs', in a course aimed at introducing undergraduate students in mathematics and computer science to mathematical thinking and the construction of proofs, with emphasis on connections with implementing mathematical definitions. This course will also be presented at ESSLLI 99. The draft textbook can be found on the Internet at address
http://www.cwi.nl/~jve/LRP

Studying

Studying Logic in Amsterdam

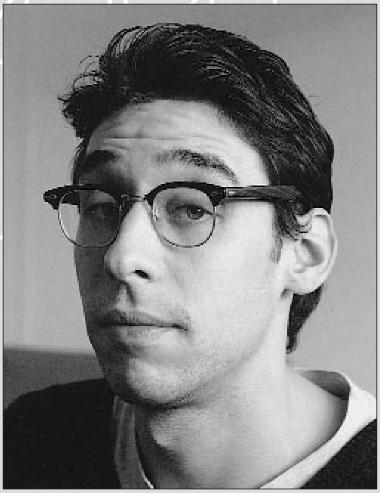


Photo: R. Verhoeve

***Walter Dean is a Master of Science student in the Amsterdam Graduate Program in Logic. He was granted the Spinoza scholarship 98/99. Information about the Graduate Program in Logic, and the Spinoza scholarship can be found at** www.illc.uva.nl/gpil*

In the United States, I am getting my PhD in philosophy from Rutgers University. My interests in philosophy are diverse, but mostly surround problems in foundations of mathematics and computer science and related questions in philosophy of mind and language which have a logical component. For instance, I am interested in both the conceptual analysis of probability and randomness and whether formal learnability theory can help to delimit the innate knowledge we must ascribe to human learners in order to explain primary language acquisition. My work has hence lead me both to consume logic as a descriptive tool for modeling cognitive and linguistic phenomena and to wish to acquire an in-depth understanding of mathematical results. As such, I have been faced with two practical problems in learning logic. First, due to my eclectic perspective, I have wanted to gain facility with a range of formalisms in logic and theoretical computer science, ranging from algebraic approaches to modal logic to various perspectives in complexity theory (e.g. Kolmogorov complexity, descriptive complexity) and the semantics of programming languages. Second, I have wanted to pursue the study of the traditional core areas of mathematical logic (model theory, set theory and recursion theory) past the introductory level.

The Master of Science program in Logic offered by the ILLC has been ideally suited to my needs. The Netherlands boasts a rich historical tradition in mathematical logic which continues to attract students and researchers in diverse fields. The program has hence given me both the opportunity to take classes in a range of fields to which I would never have access at home. It is providing a means by which I can be initiated into mathematical research at an advanced level in a field in which I had a strong antecedent interest (recursion theory).

Logic

Equally important, however, the Institute also provides a density of interest in logic and its applications which is replicated at few other institutions. One effect of this which I have noticed is that the logic faculty have developed a considerably broader approach than is common in the United States, where logic is generally treated as an isolated branch of mathematics. The wide range of formal interests represented within the Institute has led not to compartmentalization but rather intellectual cross-fertilization and a general interest in the application of logic to phenomena outside of mathematics. This has also been the source of a collateral benefit for me: both the students and faculty tend to be interested in philosophical issues surrounding their work. This has provided me with a valuable opportunity to discuss my views on a number of issues with from a number of different formal backgrounds from which I have profited greatly.

in Amsterdam

Guests, events

Logic in Action sponsored the visits of the following international guests: Grigori Mints from Stanford University; W. Blok from the University of Illinois at Chicago; V. Shehtman from the Russian Academy of Sciences; D. Miller from the University of Warwick, M. Zakharyaschev from Moscow State University; and K. Terui from Keio University (Japan).

The public visibility of the Spinoza project is also shown by the following calendar of events for 1998, with organizers indicated:

- *March 30:* **Dynamica 2**, Vrije Universiteit Amsterdam; (Paul Dekker, Yde Venema); Workshop for all Dutch researchers in dynamic semantics.

- *April 22-23:* **ALE**, Universiteit van Amsterdam; (Yde Venema); Algebraic Logic Extravaganza: an international seminar on current developments in algebraic logic.

- *April 28:* **Dynamica 3**, Universiteit van Amsterdam; (Paul Dekker); A follow-up of Dynamica 2.

- *May 18*: **C&A**, Universiteit van Amsterdam; (Paul Dekker, Jelle Gerbrandy and Henk Zeevat); Communication and Attitudes: an international seminar on communicative constraints on the notion of content.

- *May 29-31*: **WLLC**, CSLI Stanford; (Johan van Benthem, David Beaver, Rob van Glabbeek, David Israel); An annual Dutch-California workshop on new developments in logic, language and information.

- *June 5*: **Logic Dissemination Day**, Universiteit van Amsterdam; (Jan van Eijck); An exchange of experiences of logic education innovators throughout the Netherlands.

- *August 9-20*: **ESSLLI98**, Saarbrücken, Germany; (various group members); the European Summer School on Logic, Language and Information is a big, annual summer school attracting students from all over the world. The Logic in Action project was actively involved in the tenth edition of the summer school:

– Maarten de Rijke was chair of the program committee;
– David Beaver, Paul Dekker and Willem Groeneveld gave a course on' Dynamic Semantics and Information Exchange';
– Patrick Blackburn and Maarten Marx gave a course on 'Complexity of Modal Logic';
– Vincent van Oostrom and Yde Venema gave a course on 'Term Rewriting Systems';
– The Spinoza lecture was delivered by Moshe Vardi.

■ *October 2-4*: **AiML'98**, Uppsala, Sweden; (Maarten de Rijke): Advances in Modal Logic: international event exclusively devoted to new developments in modal logic

■ *October 14-16*: **FroCoS'98**, Universiteit van Amsterdam; (Dov Gabbay and Maarten de Rijke); Second International Workshop on Frontiers of Combining Systems: an international event exclusively devoted to the theme of combining and integrating formal tools and algorithms

■ On a regular, local basis, Maarten de Rijke and Renata Wassermann organized the **'Logic Meetings!'**, a weekly colloquium for the Logic Community in Amsterdam. And of course, there are running internal project seminars for the subprojects.

Plans for 1999 include:

■ *February*, **ML&Co-A**, Universiteit van Amsterdam; (Alexandru Baltag); Modal Logic and Co-Algebras: a colloquium on mathematical and applied aspects of these two fields.

■ *February*, **AAA**, Universiteit van Amsterdam; (Maarten de Rijke); Amsterdam - Aachen exchange: a day of talks from researchers from both communities.

■ *May*, **M4M**, Universiteit van Amsterdam; (Carlos Areces and Maarten de Rijke); Methods for Modalities: an international workshop on proof tools and decision methods for modal logics.

■ *May*, **Workshop on modal logics of space**, Universiteit van Amsterdam; (Marco Aiello and Yde Venema); An international workshop on formal representations of space and modal approaches to this topic.

- *August*, **ICoS-1**, Universiteit van Amsterdam; (Maarten de Rijke); Inference in Computational Semantics: a workshop on inference tools in natural language semantics

- *August*, **Logic Colloquium '99**, Utrecht University; Various group members are involved in the organization of this European summer meeting of the Association of Symbolic Logic.

- *August*, **ESSLLI'99**, Utrecht University; (various group members); The Logic in Action project will again be strongly present at this new edition of the summer school:
  – Kees Doets and Jan van Eijck will give a course on 'Logic, Representations and Proofs'
  – Sergei Artemov will deliver the Spinoza lecture
  – Johan van Benthem will give an invited lecture on 'Homo Ludens Revisited'
  – Natasha Kurtonina and Maarten de Rijke will give a course on 'Temporal Logic'
  – First Vienna Circle Lecture: a joint activity of 'Logic in Action' and the Vienna Circle Archive.

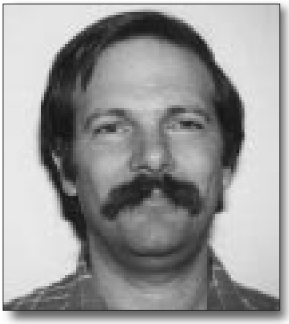
- *Autumn*, **Games**, Universiteit van Amsterdam; (Yde Venema);
  An international seminar on logic and game theory.

- *December*, **AC99**, Universiteit van Amsterdam; (Paul Dekker): the Twelfth Amsterdam Colloquium: the Amsterdam colloquia aim at bringing together logicians, philosophers, linguists and computer scientists who share an interest in the formal semantic study of natural and formal languages.

Chapter 4 THE TRUTH, THE WHOLE TRUTH AND NOTHING BUT THE TRUTH

A guest column written by this year's Spinoza lecturer Moshe Vardi

Moshe Y. Vardi is Noah Harding Professor and Chair of Computer Science at Rice University. His interests focus on applications of logic to computer science, including database theory, finite-model theory, knowledge in multi-agent systems, and program specification and verification. In 1998 Moshe Vardi was the Spinoza lecturer at ESSLLI in Saarbrücken. His lecture was about 'Alternating Automata: Unifying Truth and Validity Checking for Temporal Logics'.



A personal impression:
'My immediate feeling upon arrival at ESSLLI'98 in Saarbrücken was of being overwhelmed: two full weeks of logic and language, four sessions per day, eight parallel sessions. I was chagrined and relieved that my schedule enabled me to attend only one week. The boldness of the enterprise was overwhelming. Being used to the logic scene in the US, where making it a mainstream event is a constant struggle, I was rather struck by the vitality of the area in the European arena.'

At our request, he wrote this guest column identifying a number of major current trends at the lively interface of logic and computer science, which is also prominent in the Spinoza Project:

During the past twenty-five years there has been extensive, continuous, and growing interaction between logic and computer science. (A WWW page recently listed over 50 relevant annual events.) In many respects, logic provides computer science with both a unifying foundational framework and a tool for modeling computational systems. Thus, it has been called 'the calculus of computer science', playing a crucial role in such diverse areas as artificial intelligence, computational complexity, computer-aided design, distributed computing, database systems, programming languages, and software engineering.

In these diverse applications, certain central themes stand out, which also affect our view of what is central to logic. One is the focus on finite relational structures. Two important examples of this phenomenon are finite databases,and finite transition systems, which model finite-state systems such as computer hardware and communication protocols.

Another key theme is truth of a formula in a given (often finite) relational structure, rather than validity in all (finite) structures. This is certainly the case in database query evaluation, where we check whether a formula (called a query) holds with respect to a given database. Similarly, in model checking, which is an algorithmic method of program verification, we check whether a formula (expressing a temporal property) holds for a given finite transition system. But even applications that traditionally focus on logical validity, such as knowledge representation, might be better off focusing on logical truth. For example, planning problems in artificial intelligence can be solved using model-checking techniques.

Algorithmic techniques in computer-aided validity analysis, i.e., validity checking, and in computer-aided truth analysis, i.e., truth checking, have little to do with each other, in spite of the obvious logical relationship between truth and validity. However, we showed recently that these algorithmic techniques can be unified, at least for temporal logics - and this outcome can be extended to modal, dynamic, and description logics. The core of these technique lies in automata theory, using automata to perform logical tasks over (again) finite structures. Furthermore, they exploit the fact that most modal-style logics are in essence logics of tree structures. It is the combination of finiteness and 'tree-ness' that forms a major characteristic of current 'computational logics'.

Chapter 5 Logic in Action and its context

Logic in Amsterdam

The local habitat of the Spinoza project Logic in Action is the Institute of Logic, Language and Computation (ILLC) at the Universiteit van Amsterdam. This is an interdisciplinary distributed research community, as shown in the map below:

1 Logic and Theoretical Computer Science, Faculty of Mathematics, Computer Science, Physics and Astronomy (WINS)

2 Applied Logic Lab, Faculty of Social Sciences

3 Philosophy of Language and Philosophical Logic, Faculty of Humanities.

4 Computational Linguistics, Faculty of Humanities

In addition, some ILLC research resides at the Science Park, Watergraafsmeer, Amsterdam (not on picture)

For further information about ILLC, see the home page *www.illc.uva.nl/*

Logic in The Netherlands

The national habitat of the Spinoza project Logic in Action is the Dutch Graduate School in Logic (OzsL), whose members and associatives are shown on the map and in the table below.

Amsterdam
- Institute for Logic, Language and Computation (ILLC), Universiteit van Amsterdam
- Faculty of Computer Science, Vrije Universiteit Amsterdam
- Centre for Mathematics and Computer Science (CWI)

Utrecht
- Research Institute for Language and Speech (OTS), Utrecht University
- Faculty of Philosophy, Utrecht University

Groningen
- Institute for Mathematics and Computer Science, University of Groningen
- Institute for Behavioral and Cognitive Neuro-sciences (BCN), University of Groningen

Nijmegen
- Computing Science Institute (section Logic); University of Nijmegen

Tilburg
- Faculty of Arts, Tilburg University
- Faculty of Philosophy, Tilburg University

Information about OzsL: *www.ozsl.uva.nl*

Logic in Europe

The closest international environment of the Spinoza project Logic in Action is the European Association for Logic, Language and Information (FoLLI). The organization gathered several enterprises under its aegis, including the Amsterdam Colloquia in Formal Semantics, the London-based Interest Group in Pure and Applied Logic (IGPL), and the European Summer Schools in Logic, Language and Information (ESSLLI). The Summer Schools took place in the following places:

1989: Groningen
1990: Leuven
1991: Saarbrücken
1992: Colchester
1993: Copenhagen
1994: Lisbon
1995: Barcelona
1996: Prague
1997: Aix en Provence
1998: Saarbrücken
1999: Utrecht

Logic in Action plays a supporting role at all levels of the 1999 Summer School in Utrecht. Students can apply for a grant to participate. Logic in Action sponsors the annual Spinoza Lecture (see page 33), and moreover, most of the project leaders are involved in lecturing and in the organization. Maarten de Rijke is program chair, and members of the Logic in Action project will participate in its organization.

Logic in Action provides free membership of FoLLI for all OzsL PhD students.

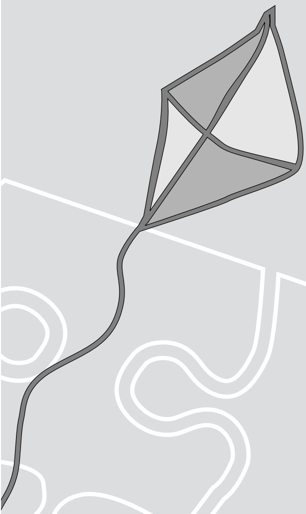
Further information about FoLLI: *www.folli.uva.nl*

AN ARGENTINIAN IN BRAZIL

Carlos Areces is an Argentinian PhD student within the Computational Logic Group. Together with Maarten de Rijke he visited WoLLIC'98, the workshop on Logic, Language, Information and Computation in São Paulo, Brazil.

After spending some days with my family in Buenos Aires, I went to São Paulo to present a paper at WoLLIC'99, the Workshop on Logic, Language, Information and Computation. São Paulo is a big city, even bigger than Buenos Aires, but when cities get that big you cannot tell the difference anymore. There is a point when 'big' and 'bigger' are the same. One hour by bus to get from the hotel to the University where the workshop was held? Great, that gave me the time to rehearse my talk once more.

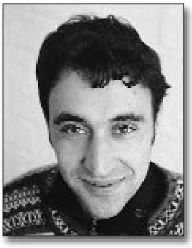
Upon arriving in the campus a beautiful surprise (the first of many): so much green. The campus seemed to be in the middle of a forest. The second surprise: to see finally the faces of the invited speakers. I imagine that it is a special moment for everybody when you finally meet personalities you have heard, read and studied about for so many years. And they were there 'in the flesh'. I went eagerly to the first tutorials. And the tutorials were good! Well prepared, coherent and at the same time pointing in so many directions. My book of notes sucked ideas as a sponge. Already at midday I had collected work for months, just to investigate all these new pointers. And the fun - because it was so much fun to listen, learn, discuss, discover new ideas - kept going through lunch... and through the afternoon presentations... and through the coffee breaks... and through the bus trip... and through the dinner... for three days! I feel now that Wollic caught us in a tide of Logic, Language and Information impossible to stop, mainly because no one wanted to stop it. It was a perfect combination of good organization, excellent disposition from the invited speakers and, of course, all the energy of the students eager to show new ideas and learn old tricks. Wollic had me so hooked that I did not manage to get to know 'São Paulo/The City' as I wanted, but I think I did manage to get a glimpse of 'São Paulo/The People'. At least I had the luck to share a good time with many of the Brazilian students taking part of the Workshop. We talked for hours in this special mixture of languages which we call 'portuñol' - where they would try to speak Spanish and I would struggle with the beautiful sounds of Portuguese -. We talked about life in Buenos Aires and São Paulo, about research in Brazil and Argentina. They introduced me to tropical fruits I've never heard of, and I complained about the 'empanadas' (a typical argentinian dish) 'Sao Paulo style'. We compared ideas, projects and dreams. Three days is not enough to get to know a person (less a group of more than ten). I don't think I'll forget in years, though, these moments we shared together. If beside its importance as a scientific event, Wollic continues to offer the opportunity for this kind of 'growing together', then I hope the event will survive the very difficult times Latinoamerican countries are now enduring.



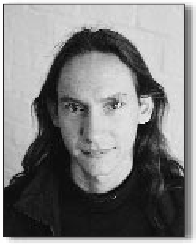
Chapter 6 Our people

As our project develops, we have been able to attract a number of people for varying periods, and to varying degrees, some paid, some volunteers on loan from other projects at ILLC or beyond.

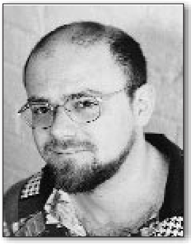
In 1998, our total group involved the following people (in alphabetical order):



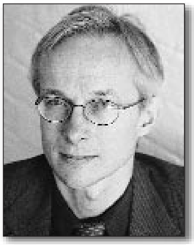
Marco Aiello (Ph.D. student, computational logic)



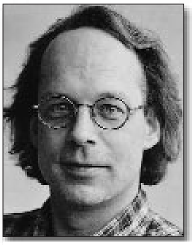
Carlos Areces (Ph.D. student, computational logic)



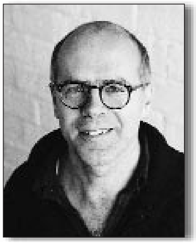
Alexandru Baltag (post-doc, co-algebra and modal logics)



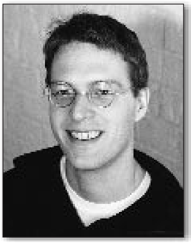
Johan van Benthem (project leader)



Paul Dekker (project leader 'Logic in Communication')
(Photo: R. Verhoeve)



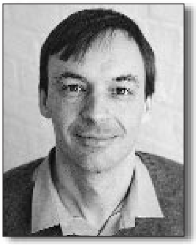
Jan van Eijck (project leader 'Dissemination of Logic')



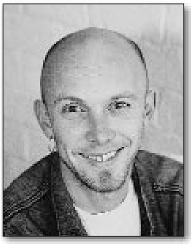
Jelle Gerbrandy (post-doc, epistemic dynamic logic)

Jan Jaspars (free-lance logician, applications of modal logic)
(Photo: R. Verhoeve)

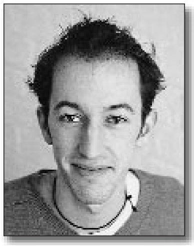
Ingrid van Loon (business administrator)



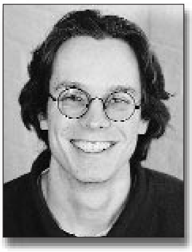
Hans de Nivelle (post-doc, theorem proving)



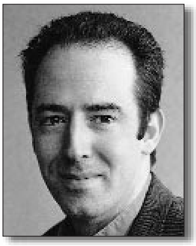
Maarten Marx (post-doc, modal logic)



Christof Monz (system administrator, computational logic)

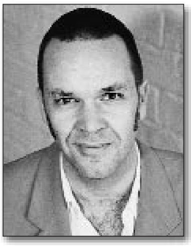


Marc Pauly (PhD student, dynamic logic hypertextbook)



Maarten de Rijke (project leader 'Computational Logic')

(Photo: R. Verhoeve)



Yde Venema (project leader 'Logic in Communication')

Not on picture:

- Lex Hendriks (post-doc, computational logic)
- Gwen Kerdiles (PhD student, computational logic)

In February 1999, Annette Bleeker joined the group, working on a PhD thesis on encrypted message passing. One month later so did Christof Monz, as a PhD student working on information retrieval and extraction. Furthermore, in 1999 we hope to attract a PhD student on a project involving structuring of electronic information and another PhD student on the dynamic logic programming.

Epilogue Learning and Teaching, a tale across the centuries

An afterthought of Johan van Benthem

Research stands much higher in the order of academic prestige than teaching, despite valiant efforts by university authorities to create more of a balance. Now, our Spinoza project has an undisguised didactic component, next to the modeling, theorem-proving, and computation efforts high-lighted in our introduction. Why? There is our overflowing need to communicate good things, of course. But more fundamentally, teaching and learning are integral aspects of our scientific concerns. Logical analysis of reasoning and communication tends to describe the 'steady state' of competent practitioners, that make information flow so smoothly. But at least as great a miracle are the processes whereby we come to learn these things, or teach others what we ourselves know already. And yet, we do not even know the best didactic way of presenting logical reasoning! Spinoza published his 'Ethica more geometrico demonstrata' in axiomatic-deductive format. The advantages were clear. The definitions set out one's assumptions explicitly - a virtue in the volatile area of morality and value - while the proofs interconnect one's judgments precisely, opening up new avenues of thought. This geometric mode was popular in the 17th Century. Johan de Witt chose the same format, when asked by the States General to explain his proposals for exact pricing of life insurance - the first ever! - to a general public. (On the eve of an Anglo-Dutch War, money had to be raised quickly.) 'Waerdije' addresses the Dutch citizens in axiomatic style on mathematical expected values, with illustrations of betting on jewels, it then compiles mortality statistics, and proves substantial theorems for good state finance that is fair to citizens. The mayor of Amsterdam, Johannes Hudde, himself a known mathematician, wrote a brief validation at the end. Those were the days! But the axiomatic-deductive style also has its drawbacks. Imre Lakatos has shown in his book 'Proofs and Refutations' how much livelier things can be in the actual process of discovering mathematical laws, where counter-examples and revision abound. Students should also learn things by trial and error then, with Euclidean proofs coming last. In addition to proof and truth, however, our modern Spinoza project emphasizes games. Well...game-theoretic models of exposition go back to Leibniz's 17th century account of continuity, where one player sets an approximation bound for a value, and the other must give an approximation bound for the argument such that all function values inside the latter 'hit' inside the former. Continuity holds for a function if the second player has a winning strategy. More generally, winning strategies for argumentation are what logic is all about - and such games can be played in class... This columnist, for instance, has played logic games in classrooms from The Netherlands to Taiwan, and their rights, duties and dynamics are equally vivid across cultural barriers. So, is our 'learning playing, and playing learning' - in the words of our national poet Hieronymus van Alphen two centuries ago? Not quite. Every teacher knows that one may teach two identical courses to similar audiences, and yet obtain very different results. The difference is emotional chemistry between people. Emotions, of course, are a key 17th century theme - from the intellectual emotions listed in Spinoza's 'Ethica' to the highly charged ones of Pascal's 'Pensées', that light up our lives.

Institute for Logic,
Language and Computation

Universiteit van Amsterdam