INSTITUTE FOR LOGIC,
LANGUAGE AND COMPUTATION

Logic in Action 1999

AN NWO SPINOZA AWARD PROJECT

NWO

UNIVERSITEIT VAN AMSTERDAM

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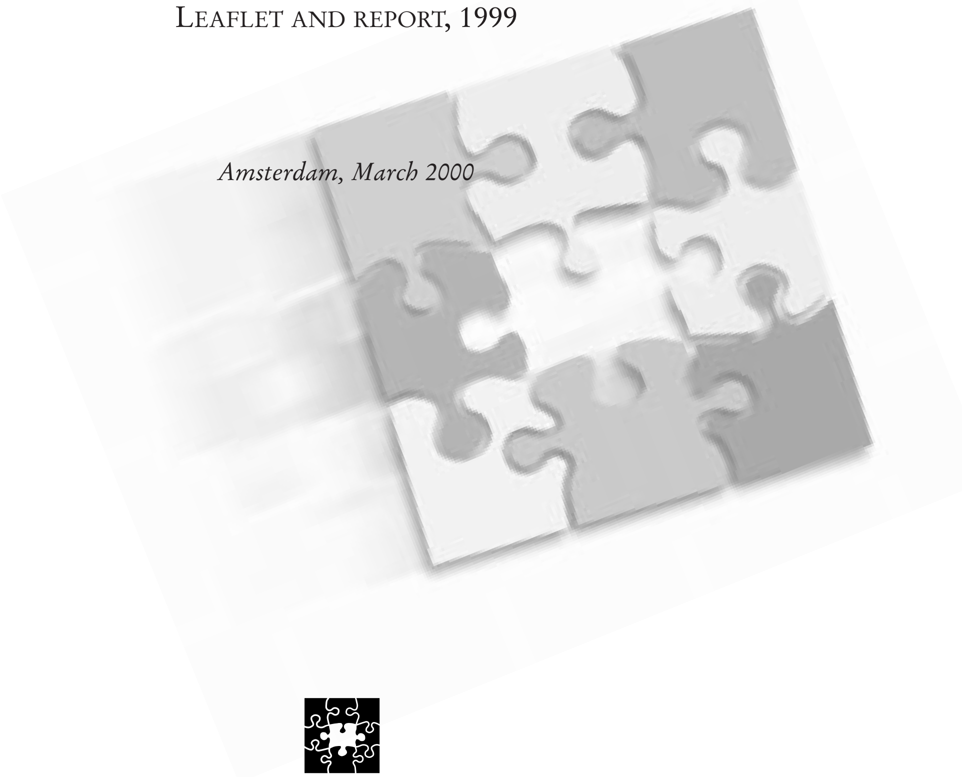
LEAFLET AND REPORT, 1999



Amsterdam, March 2000

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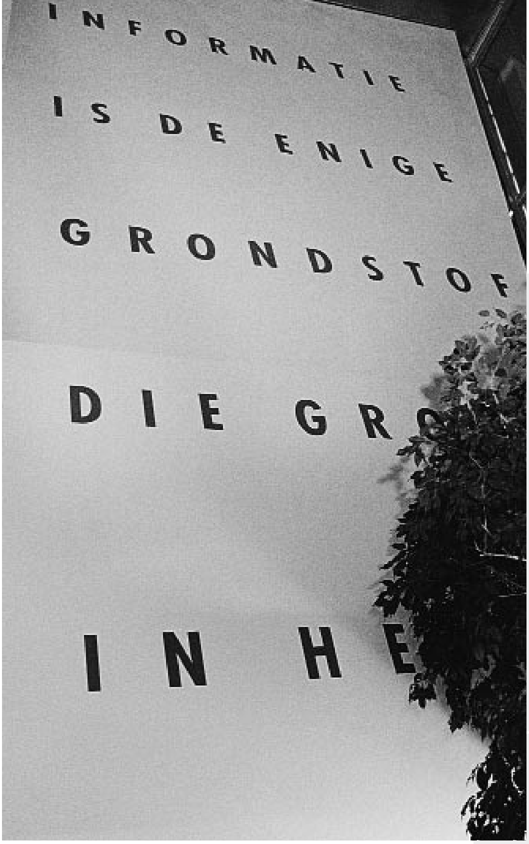


Johan van Benthem's motto 'Informatie is de enige grondstof die groeit in het gebruik' or 'Information is the only resource that grows with use' several meters high on the wall of the library of the Technical University Delft

Logic in Action 1999

An NWO Spinoza Award Project

Dear reader,

We are proud to present the 1999 Spinoza brochure, the third annual report of the Spinoza project Logic in Action. *Logic in Action* is an initiative of Johan van Benthem, professor of Mathematical Logic at the Universiteit van Amsterdam. In October 1996, he 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.

This brochure gives an impression of the general aims of the project (section 2), and the project activities carried out by its research members in 1999 (section 3). Other sections include a guest column by Sergei Artemov, the embedding of Logic in Action in a larger context and the sections are intertwined with short texts on various related topics. A preface and epilogue are written by Johan van Benthem himself.

We hope you enjoy reading it.

The editors

Contents

Preface

Mechanisms of Information Flow

The present is often not the best vantage point for seeing progress in research. Successive Spinoza years provide a better strategic perspective. What has happened so far in our project? The main theme in my public NWO acceptance lecture (October 1996) was the dynamics of informational update.
I demonstrated how logical inferences induce successive modification of hearers' information states by the premises, followed by a check for the conclusion in the resulting state. This 'direct update' concerning facts for hearers or readers works for the simple logic puzzles that commuters do on trains, or for popular games like 'Master Mind', where one player has to guess the positions of some coloured pegs through answers to successive conjectures. Let me now take the story of logical information flow a little further.

Real communication is much more complex than one-sided factual update, as it involves 'overtones' of knowledge and ignorance about other people's information. If I ask you the way to the Central Station - under normal circumstances, my question tells you that I do not know its location, while I expect you to know. After you have given the answer, we both know its location (a plain fact), but we have also achieved so-called 'common knowledge' about our little group: I know that you know that I know, etc. This extra information is not just a byproduct of our meeting: it can be crucial to our further actions. Indeed, humans are remarkably good at keeping track of who knows what about whom, and responding to fine distinctions. Everyone's knowing that your partner is unfaithful is just a nuisance, which may be ignored - if everyone also knows about the others' knowledge, you have shame and social disaster, and it may be time to draw your shotgun and contemplate a crime of honor.

The road to the Central Station took me to a lunch with NWO's 1999 Spinoza selection committee, where we spent pleasant time scribbling 'group information diagrams' for such knowledge overtones on handouts and napkins. Mathematical models of this kind were found by logicians in the 60s, and independently by economists in the 70s, who studied rational decision in groups of agents. Giving a straight answer to a question is a case of update of group knowledge under public announcement, which transforms such group information diagrams. This phenomenon was first studied by computer scientists in the 80s. Our Spinoza postdoc Jelle Gerbrandy found an algorithm for both public announcement and 'screened announcements' (made available only to privileged subgroups) which has quickened the pace of research considerably. His algorithm eliminates positions in the information state that are incompatible with the new information, while taking care in subtle ways that this cannot be noticed by those outside of the relevant subgroup of 'cognoscenti'.

A natural setting for many-agent updates are games, the theme of the Preface for the 1998 Spinoza brochure. In particular, its 'challenge of the envelopes' has been solved in the meantime by various people, including our Spinoza postdoc Alexandru Baltag. He designed a logic of communicative action that explains the changes in information for players in the course of a game through their inability to distinguish various actions by their opponents. This is one of many game-theoretic strands. This fall, Spinoza Ph.D. student Marc Pauly organized a workshop on 'Logic and Game Theory', bringing together some 40 people at this interface. New turns presented included an update analysis of questions as signals for decision problems, and an extension of public updates to Bayesian ones by our Groningen colleagues, addressing unresolved issues in probabilistic reasoning. A healthy injection of realism was Hans van Ditmarsch's work on information flow in actual card games like 'Cluedo'. But there is still more to the game-theoretic connection. Players do not just convey information about facts, or their own information. They also play strategies - and through a game, I must ponder what I am learning about your probable future behaviour towards me. Thus we leave the mere logical space of all possible updates, and encounter issues of navigation: optimal queries, and best actions for achieving individual or collective goals. Ariel Rubinstein's text in this brochure speaks to these exciting connections, where economics meets logic, computer science, and linguistics.

Public announcement also emerges on a different theatre of the information society. Most update logics for natural language address communication between agents eager to inform. The situation gets more subtle in card games, where I must answer truthfully, but need reveal only as little as I please. At another extreme, internet protocols wish to hide as much as possible of our communication, at least to others. This is the world of secrecy and security protocols. These, too, can be studied with the tools that we are developing, witness new work by Annette Bleeker and Jan van Eijck on updates using encoded messages over a public broadcast system. The challenge here is very practical. It is literally unknown if major current security protocols have the effects intended by their designers, and users.

NWO's 'Nationale Wetenschapsquiz' of this year contained a question about 6 people each possessing a secret, and the smallest number of communication steps needed for them to achieve universal possession of the 6 secrets. This small, but clever instance of update thinking (where all live participants on TV guessed wrong) shows, to my great gratification, that the mechanics of information flow has by now reached the masses and their media.

Section 1 The spinoza program of NWO

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 complies with 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.

Since 1995, the first year of the Spinoza programme, the grant has been awarded to 17 scientists. In 1999 the prize winners were:

- Prof.dr. C.W.J. Beenakker (theoretical physics, Leiden University);
- Prof.dr.ir. R. de Borst (applied mechanics, Technical University Delft);
- Mrs.prof.dr. E.A. Cutler (comparative psycholinguistics, Catholic University Nijmegen and director Max-Planck Institut für Psycholinguïstiek in Nijmegen);
- Prof.dr. R.H.A. Plasterk (molecular biology, University of Amsterdam and Netherlands Cancer Institute)

Section 2 LOGIC IN ACTION

> τοῦ λόγου δ΄ἐόντος ξυνοῦ
>
> THE LOGOS BEING COMMON
> HERAKLEITOS, 2-ND FRAGMENT

τοῦ λόγου

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 various disciplines ranging from linguistics and philosophy to mathematics, and from computer science to psychology and the social sciences. The ensuing interactions generate a remarkable convergence of techniques and ideas. We actually observe a new natural grouping of research efforts into what may be called the ‘information sciences’. The aim of the *Logic in Action* project here is to act as a catalyst and to found, further and extend the role and scope of logic as a core discipline in information scientific research and education. Logic can be assigned such a key role, as it figures as a calculus for the information sciences. In this section we describe the *Logic in Action* project, both against the background of logic as a canonical academical discipline, and with an outlook upon logic as an active branch in the evolving information society.

Logic...

For long, from the Ancients on, logic as a discipline has been concerned with the rules of valid inference and meaning, abstractly conceived. Thus, inference patterns are classified as valid if they are set up according to strict laws of reasoning, or if the reached conclusions are forced, according to such laws, by preceding premises. For example, a classical line of reasoning is that of ‘modus tollens’:
(1) if P then Q
(2) not Q
(3) so, not P

Similarly, a notion of validity or entailment has also been classified in terms of meaning or truth-conditions. A sequence of premisses is said to entail a certain conclusion if the latter is true in all the models or ‘possible worlds’ in which the premises are true. If it is inconceivable that there is a situation in which the premises are true, and not the conclusion, then it is deemed a logical conclusion.

However, logic in its colloquial sense is an enterprise encompassing more than the rules of correct reasoning only. People say, for instance, that they don't understand 'the logic of this printing device,' and talk about 'the investor's logic,' or 'parental logic,' etc. Also, the semi-productive suffix '-logic' appears to relate to more than the domain of valid reasoning, as it appears in 'psychological considerations,' 'polemological motivations,' 'chronological variations,' and, if you want, 'egological' or 'agnostological limitations'.
Last but not least, the term 'logic' is etymo- *logically* related to the Greek word λόγος, which was used for a wide variety of concepts such as language, understanding, reason, doctrine, structure, and principle. It appears that logic, basically, is not just concerned with the patterns of valid inference, but with the ways in which cognitive human agents structure their interaction with their immediate natural habitat (which includes other agents).

The last century has witnessed an increasing tendency in which logic recaptures its initial, more ambitious, scope. Although logic as a discipline, in the division of labour between the major disciplines of (Western) thinking, has traditionally been granted the rules of inference only – and although it has fallen asleep for ages every now and then – it has woken up in the late 19-th century with the work Boole and Frege, and it has revived and grown strong in the second half of the last century. Nowadays, and also most explicitly in the Logic in Action project, logic has an open eye for the phenomenon of information management, and it gets applied in other rule-governed contexts than that of reasoning only: in mathematics (calculation rules), in linguistics (dialogue and interpretation rules), in natural language processing (rules of computation), and recently logic reasoning is also located in the context of action and decision (rules of the games people play). This last point relates to another classical logico-philosophical issue, concerned with how 'good' the world is, and what we can do about that.

...in Action

In previous eras philosophers have discussed the question whether or not we inhabit the best of all possible worlds. Leibniz, for instance, concluded we did: 'Ainsi on peut dire que de quelque maniere que Dieu auroit crée le monde, ... Dieu a choisi celuy qui est le plus parfait, c'est a dire le plus simple en hypotheses et le plus riche en phenomenes ...' (Discours de Metaphysique §6, 1686; Voltaire, by the way, ridiculized this idea in his famous 'Candide').
In traditional logic, possible worlds have been dealt with in a more unbiased or abstract, set-theoretical sense. They have been used simply to represent the way

The Computational Logic group: at the back: Jon Ragetli; in the middle: Marco Aiello, Alexander Bergo; in the front: Christof Monz, Carlos Areces. Not on picture: Maarten de Rijke (project leader), Rosella Gennari, Gwen Kerdiles, Breanndán Ó Nuállain, Krzysztof Apt, Lex Hendriks

the world might be according to the information of agents, or the way they might want it to be given their desires. No arbitration between these worlds takes place, except, possibly, for the assumption that one possible world is the actual one. However, here as well, things have changed.

For instance, in modal and action logics and in game theory, reasoning and interpretation are placed back right in the context where they occur: in the context of the agents' situation, her beliefs and her desires. The general assumption is that agents, besides deliberating about the question whether we inhabit the best of all possible worlds, also seek to optimize their environment so as to create or maintain the best possible world attainable to them. Here, optimization is the key notion by means of which rational behavior, including the linguistic behavior involved in information exchange, gets analyzed.

Let us illustrate this with a couple of examples.
If we hear that it is just not true that Bernd is not going to sell his shares in MacroHard, then most probably he is going to. But maybe he is not in a position to do this, either because he doesn't own any, or because he is simply out of control. The right interpretation of what we hear depends on an optimal

Mission Statement

The general aim of the Spinoza project Logic in Action is the development of an international and interdisciplinary centre in which logic figures as the core discipline for an emerging information science. Logic in Action focuses on research (strenghtening the contacts between alpha, beta and gamma research disciplines), implementation (foundation of a computational logic laboratorium), and education (promotion of logic education to the general public).

rendering of the utterance relative to the utterance situation, including what we know about the speaker's beliefs and intentions and those of Bernd. Similarly, we can explain or motivate someone's actions on the stockmarket in terms of her expectations about the other players' rational reactions to the recent fluctuation of the shares of, say, Quantification and Co. Notice that, in both examples the expected actions or interpretations of the other players depend on that of one's own, so that a logical best response depends on a deliberate assessment of the practical and epistemological situation. This is where dynamic and epistemic logic come in.

Optimization also proves to be a logical respons to socio-political matters. Think of two hypothetical countries, Taxonia and Fraudesia, which have exactly the same social-economical system, but a different practice. In the first, people generally pay taxes because they do not want to erode the social security system; besides, the chance of being caught if one doesn't is high. In the second, however, nobody does, because nobody else does, nobody wants to be a thief of his own wallet, and because the chance of getting caught is small. Thus described, both systems are equilibria ('steady states') in both an intuitive sense, and in the formal sense of game theory. Now think of a group of policy-makers of one of the two countries, who want to transform existing practice into that of the other. Obviously, this involves reasoning about the games people play, and the ways in which they play these games when the settings are changed. Ideally, logic is the instrument to analyze, motivate or denounce the plans which the policy-makers might come up with.

Logic in Action Themes

Surely it is preposterous to think that present day logic is able to change, say, the habits of tax-payers in the foreseeable future. However, it is equally inconceivable that we were to neglect the logical inclinations of the players in the emerging information society. Logic, understood in a broad sense, eventually ought to provide us with the tools and concepts to approach and analyze this realm of information interchange.

The Amsterdam Colloquium

The Amsterdam Colloquium, a Retrospective

The year is 1976. Linguistic semantics has gone through a radical change in the preceding years. The work of Richard Montague, David Lewis, David Kaplan and others, has opened up new ways of doing semantics, and promises to bring together the tools and methods of the logicians with the empirically oriented work of the linguists. A small community of Dutch philosophers, linguists and logicians prepare for what eventually proved to be the first of a series of meetings that still take place today. The first meeting hosted a small number of participants, of which some had been 'eye witnesses' to the new developments. Renate Bartsch, for example, had already taken an active part in shaping and promoting the logical way of doing semantics, and so had Hans Kamp, then teaching in London, who was a former student of Montague's himself. Other participants had just taken their first steps into the new territory, and yet others were completely 'fresh', curious to find out what the 'fuss' was all about.

AC 03: 1980

The first meeting was followed up by others, and, over the years, the Amsterdam Colloquia have witnessed the emergence (and also decline) of various trends and developments. With the first three colloquia Montague Grammar got an operating base in Europe, while the Colloquia also attracted leading semanticists from the US, such as Bach, Dowty, and Partee. Pragmatic and information-oriented approaches to interpretation made their appearance at subsequent meetings in the eighties, where the Colloquia attracted logicians and semanticists such as Barwise, Halpern, Hintikka, Kratzer and Stalnaker.

AC 07: 1989

In the nineties the colloquia provided an outstanding platform for logical formalisms like categorial grammar and dynamic semantics.

By now, the Colloquium series has grown into a regular, biennial event with a fair amount of inevitability. The last Colloquium, the twelfth, was held in December last year, and like the previous one, it was partly funded by the Spinoza project 'Logic in Communication'. Also this meeting witnessed the emergence of a new theme, the application of game- and decision-theory.
Over the years not only the theoretical scope of the Colloquium has grown, but also its geographical scope. While the first meetings were by and large a Dutch – German tête-à- tête, participants nowadays come from all over Europe, former Sovjet republics, North and South American countries, East Asia and Australia. If, at the next Colloquium, our African contacts make their way to the Colloquium, this only leaves Antarctica as the unaffected continent.

In all the years, the aim of the Amsterdam Colloquia has remained that of providing a platform for state of the art research, and if we may believe one of the leading semanticists in the United States, prof. Barbara Partee, it still succeeds in doing so. In the program booklet of the Tenth meeting she wrote: 'Until the advent of the annual SALT meetings in the U.S., which started in 1991, the biennial Amsterdam colloquium was the meeting in this field, and it remains one of only two regular occasions for presenting one's newest work to an optimal audience.'

AC 12: 1999

Paul Dekker
Martin Stokhof

The Spinoza project *Logic in Action* explicitly aims at enhancing and furthering the scope and role of logic in an upcoming information science.
In the project logic constitutes the common approach to information, information flow and information exchange, and by locating information, interpretation and reasoning in the context of rational, decision making agents, a focus of common interest is created for various disciplines.

Of course, for such an enterprise to be feasible, deliberate choices have to be made, and themes have to be selected to focus upon. We mention three themes which illustrate the interactions between logic, linguistics, mathematics, and computer science characteristic for the ILLC research environment. These themes reflect and enhance the long-standing tradition of information-oriented logic in Amsterdam with such highlights as intuitionistic and modal logic and dynamic semantics.

Dynamic models of information and communication
A central aim of the Spinoza project is the design and study of formal models of the patterns of information and information flow. Even in the simplest forms of communication diverse notions such as knowledge, physical action and information change are intertwined, and a multi-agent perspective is called for. 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. More on the empirical side, we are after a formal characterization of the linguistic 'presuppositions' for successful information processing. A unifying perspective is looked for in the area of game theory, whose (modal) logical properties are investigated.

Correspondences between computation and information processing
Modern information technology has blurred the borderline between natural and artificial languages. A similar blurring of boundaries reveals itself at the level of foundational research. The 'dynamic turn' in the semantics of natural language was partly inspired by the theoretical study of the semantics of programming languages: a command like 'increase the value of register X by 1' relates an 'old' memory state to a 'new' one. Similarly, mention of a new topic of conversation in natural language relates an 'old' context of discourse items to a 'new' one. Interestingly, one of the tools designed for the analysis of this context change phenomenon in natural language, dynamic predicate logic, gives rise in turn to a computational interpretation: dynamic predicate logic can be turned into a programming language. By the looks of it, programming with natural language is just around the corner.

THE DISSEMINATION OF LOGIC GROUP: AT THE BACK: JAN VAN EIJCK (PROJECT LEADER); IN THE MIDDLE: JUAN HEGUIABEHERE; IN THE FRONT: MARC PAULY. NOT ON PICTURE: HANS DE NIVELLE

Modular reasoning with light-weight representations

Informatics has become a common name for the new science of information, together with its associated applications and human dimensions. One of the most pressing issues facing informatics is content finding, accessing, structuring, and presenting the information we need. Content can be represented in many ways, ranging from simple keywords to light-weight semantic analyses to deep ones. The key challenges is to understand the balance between the richness of representations and the computational efficiciency of constructing representations and reasoning with them. The strategy we have adopted is a mixture of foundational and experimental work with an emphasis on developing small, dedicated logical techniques and lean natural language processing tools. Novel in its avoidance of baroque supersystems, this project analyzes semantic complexity, makes it explicit, and harnesses it.

Structure

The main activities of the *Logic in Action* project are clustered in three overlapping groups, which are allocated to three, mutually related, subprojects.

Logic in Communication sits at the interdisciplinary interface between humanities and exact sciences, aiming to contribute to further 'alpha-beta-ization' of the university. In this subproject, dynamic, modal and epistemic logics are applied in the study and formal modeling of information and its flow, with an eye on characterizing the properties and structures essentially required for successful processing, in natural as well as artificial contexts. 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. Modal logic is pleasantly robust in its balance between expressive power and computational simplicity, while retaining a nice metalogic.

THE LOGIC IN COMMUNICATION GROUP: AT THE BACK: MAARTEN MARX; IN THE MIDDLE: PAUL DEKKER (PROJECT LEADER), ANNETTE BLEEKER, ALEXANDRU BALTAG; IN THE FRONT: YDE VENEMA (PROJECT LEADER). NOT ON PICTURE: JELLE GERBRANDY

There is also a more practical strand running through the Spinoza project. *Computational Logic* is a pilot project for making computational concerns and facilities an essential part of our research efforts. Thus, the project's name is taken quite literally. The group's ideas are put to work in actually implemented systems. One particular effort is the construction of effective theorem provers and model checkers for formalisms like modal logic or the guarded fragment of first order logic, 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 made publicly available on the Internet.

Dissemination of Logic is a kernel project for translating the group's research efforts into insights and tools for a larger community. 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.

Besides the three subprojects, 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!

Logic and action constitute the backbones of all activities undertaken in the Logic in Action project, theoretically (research, formal modeling) as well as practically (computation and implementation, education and dissemination). As, we hope, the following report on the project's activities in 1999 shows, the project is the natural habitat for logicians who initiate activities.

Paul Dekker

Logic and Economics

Ariel Rubinstein is professor at the Department of Economics of Tel Aviv University, and Lecturer in Rank of Professor at the Department of Economics of Princeton University. He visited the University of Amsterdam to give an invited lecture on Economics and Language at the Logic and Games workshop, organized by the Spinoza project in November 1999.


Bangkok traffic

'Imagine that you are participating in a public debate on the level of education in the world's capitals. You are trying to convince the audience that in most capital cities, the level of education has recently increased. Your opponent is challenging you with indisputable evidence showing that the level of education in Bangkok has deteriorated. Now it is your turn to respond. You have similar indisputable evidence to show that the level of education in Mexico City, Manila, Cairo and Brussels has increased. However, due to time constraints, you can present evidence for only one of the four cities. Which city would you choose to make the strongest counter-argument to the Bangkok results?'

If you are like most of the subjects in the experiment conducted by Jacob Glazer and myself, you will feel that bringing forth the evidence about Manila is the best option. If you do not respond to Bangkok with Manila and the listener knows that you are familiar with the Manila evidence, he will probably infer from your counter-arguing with Cairo, for example, that the case of Manila does not support your position. If you had to rebuff evidence about Amsterdam, you would probably find Brussels the best counter-argument. This is a bit 'strange' as all four cities have more or less the same information value.

We view the procedures of debates and the rules of persuasion as a game played by debaters who wish to win the debate. We argue that designing rules of debates and rules of persuasion to serve the listener's interests best may be consistent with phenomena of the type exhibited by the above example. More generally, our research is part of a program aiming to explain phenomena from pragmatics using theoretical economic methods.

The reader may wonder how it is that questions from the philosophy of language are of interest to an economic theorist. Note that economics is not only about the issues appearing in the economics sections of daily newspapers. Economic theory is an attempt to explain regularities in human interaction and the most fundamental non-physical regularity in human interaction is our language. In economic theory we have studied, quite carefully, issues concerning the design of social systems; rules for interpreting conversations or debates are important parts of our social interaction. We have tried to explain social institutions as regularities derived from optimizing certain functions which they serve. In this project we try to apply the economic methods for investigation of language as well.

Ariel Rubinstein

Section 3 Logicians in Action 1999

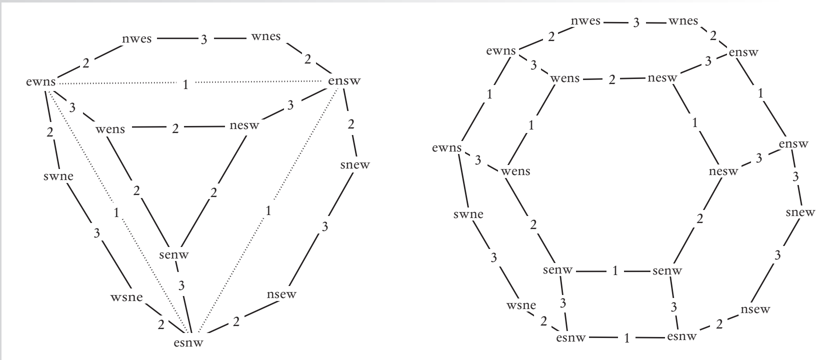
The year 1999 was the year the *Logic in Action* project started to operate at full speed. In this section we report on the main research activities of the three subgroups, and list the most important activities and events that have been organized.

Logic in Communication

The *Logic in Communication* project is concerned with the formal study of communication and information flow. The objective is the development and study of formal mathematical tools for the analysis of communication in both natural languages (linguistics) and artificial ones (computation). With the objective of a calculus of information science, the Amsterdam traditions in dynamic semantics (interpretation), and modal logic (information), and the reviving field of game theory (action) find a point of convergence.
Amsterdam is an international centre for modal and related logics, which provide us with a mathematically sound basis for the study of formal and logical properties of information, information gain, information loss, and directed information exchange. The paradigm of dynamic semantics feeds the logical one with conceptual and computational issues which arise in the study of natural language interpretation and reasoning. Game theory and action logic, finally, show up as the natural theoretical environment for the characterization of communicating agents, their communicative (non-)actions, and the information they have or fail to have.
In 1999, when the group had become fully equipped, we have gained increased theoretical grip on information flow from all three perspectives.

One of the main theoretical themes relates to the startling issue of modeling 'Who knows what?' in distributed information environments. In most formal and natural life applications, some agents know particular things, certain agents exchange part of this information to other agents, and some, but not all, agents monitor these exchanges. In these environments the question pops up 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 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 deep foundational issues have been addressed here, by Alexandru Baltag and Jelle Gerbrandy most in particular. It has been shown that classical set-theory does not provide the most

The formal representation of epistemic space in a simple game (©Hans van Ditmarsch)



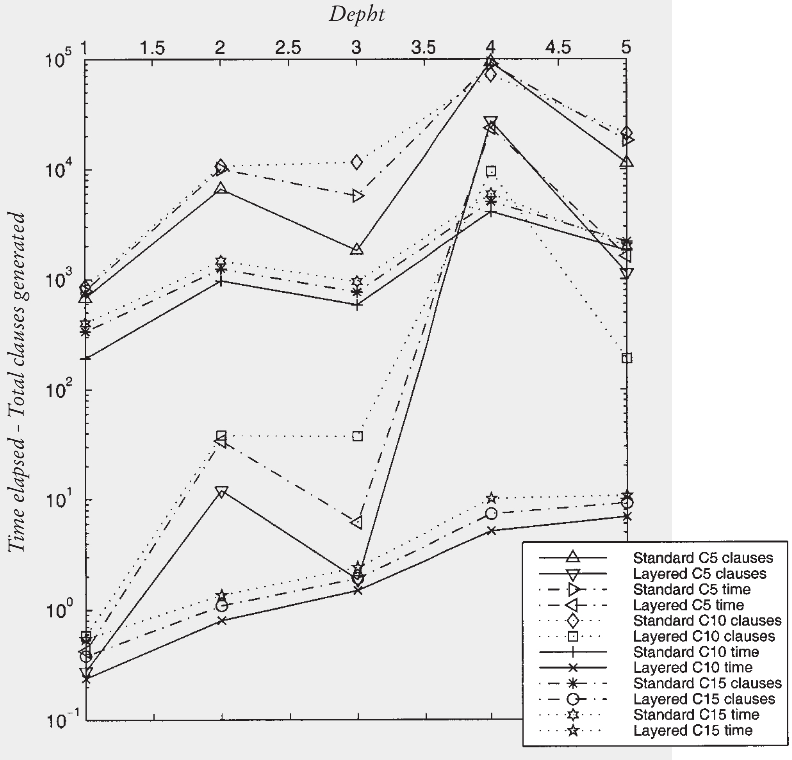
adequate setting for dealing with the concept of information change in a multi-agent environment. Rather, the more general framework of non-wellfounded set theory, and the associated co-algebraic techniques, have been called for. It has been shown that the newly developed perspective successfully applies to several semi-paradoxical issues in the dynamics of information exchange (such as e.g., the puzzles of the dirty children, or that of the surprise exam). On a more mathematical level, Alexandru Baltag and Yde Venema investigated the connection between modal logic and co-algebras further. Also in other respects we have proceeded on the road that we have taken in 1998; for instance, we have widened the range of our work on formalizations of communication processes, taking more aspects of communication into account as e.g. in Annette Bleeker's work on encrypted message passing.

In the area of dynamic semantics, Paul Dekker and others have shown that the dynamics of interpretation is better conceived of as the dynamics of language use, rather than that of linguistic meaning. In this way we can not only recover the connection with the classical, philosophically well-motivated semantic paradigm, but this also enables us to generalize the dynamics of interpretation, to take into account the speaker's role in felicitous information exchange, and to extend the empirical scope of the dynamic paradigm. More in particular, this shift allows us to explain and motivate suitable and rich pragmatic interpretations of various connectives on the basis of a transparent logical semantics. The dynamics of the semantics / pragmatics interface has also taken us to study the, upcoming, optimality theoretic approach to interpretation and its relation to game theory. In optimality theoretic semantics, interpretation is guided by constraints which are not hard, but 'violable' and of different strengths. Together with Robert van Rooy, Paul Dekker has shown that optimality of interpretation can be characterized in terms of games, in which one agent (the speaker) chooses an optimal formulation from a set of candidate utterances in order to express his intentions, and another (the hearer) chooses an optimal interpretation from a set of candidates in order to retrieve the intended meaning. With this outlook upon linguistic action as a coordination game, felicitous exchange can be characterized as a game-theoretical solution concept.

Especially in the realm of action and knowledge the joint group has studied and applied game-theoretical methods. Game theory provides us with a framework that is on the one hand rich enough to be interesting for a general theory of communication, and on the other hand restrictive enough to allow for a rigid and elegant mathematical analysis. Game theory is also attractive because it has such a wide range of applications, running from economic theory to the semantics of formal and natural languages. As an example, take the so-called 'games of imperfect information' in which agents have to make moves without exactly knowing what is going on. Such a setting really is characteristic for agents in any natural environment, but, even in laboratory environments, it is unclear what this amounts to from an information-theoretic perspective. Our interest has been both to test the feasibility of the game-theoretical paradigm as a formal tool for approaching these questions, and, on the other hand, to analyze the game model itself in terms of modal logic. A second and more theoretical example is formed by the game-theoretical analysis of the formal semantics of logic itself. There are interesting and direct parallels here with systems of dynamic semantics, parallels which have been used to explain and even improve dynamic semantic principles of interpretation.

Computational Logic

The mission of the *Computational Logic* project is to put to work the abstract theories and logics developed at the Institute for Logic, Language and Computation. Building on traditional themes of the institute, such as modal logic and natural language semantics, the Computational Logic group is



The plot shows how the new Layered translation of modal formulae into first-order logic devised by the Computational Logic Group improves the performance of a resolution theorem prover with respect to the standard relational translation. Both the needed CPU-time and number of clauses generated to find a proof have been greatly reduced. We display average behavior on test obtained using the random generator approved by TANCS (Tableaux Non Classical Systems Comparison).

focused on content, and on representing, accessing, and manipulating content in textual and non-textual form. Our leading strategy is the development and deployment of dedicated 'variable weight' methods: methods that allow us to represent content at appropriate levels of detail and analysis, with suitable algorithms to match these representations. Such specialized methods are then combined, in a modular way, to address more ambitious content-manipulation tasks. This strategy is a multi-faceted one, raising both foundational questions (to what extent is efficiency representation-independent?) and experimental challenges (what kind of representations turn a task such as subsumption checking into a do-able task?); the group's research activities cover both of these aspects partly in projects involving industrial partners.

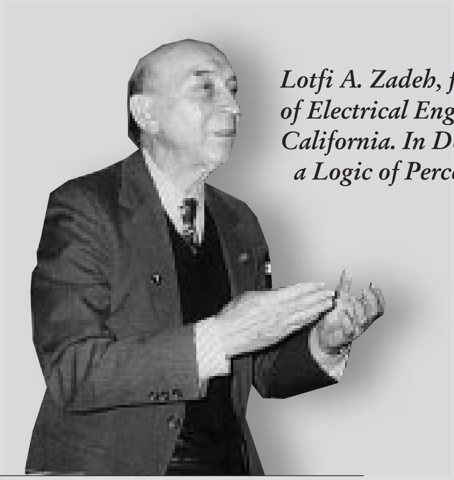
More specifically, work within the Computational Logic group is organized in three streams: Computing with Logic, Computing with Language, and Computing with Information. During 1999, each of these streams gained full speed, both in terms of the number of people involved and in terms of research activities. By the second half of the year, a total of 12 people were directly involved with the group.

The Computing with Logic stream provides a natural setting for the group's focus on content, and, especially, for investigating the balance between representations of content and methods for manipulating content. One of the main foundational issues here is to determine how the expressive power of a description formalism is related to the computational costs of performing reasoning tasks within the formalism. Here, a step forward was made by Kurtonina and de Rijke when they fully mapped out the relative expressive power of a large family of description logics; the relationship between various classes of such logics were studied by Areces, Kerdiles, and de Rijke, using a variety of computational and logical criteria. A more direct way of understanding the balance between representations and efficiency is by experimentally comparing the computational properties of different representations. This line is being pursued by Ó Nualláin in the setting of propositional logic, and by Areces, Gennari, Heguiabehere, and de Rijke in the setting of modal logic, where they exploited important semantic properties to optimize the performance of translation-based theorem provers. More practical concerns stemming from the area of telecommunications have been driving a related research question: How do we represent dynamic and possibly conflicting information from different sources in a controlled and efficient way? Accorsi, Areces, Bouma (KPN Research), and de Rijke have investigated two novel and complementary lines of attack here, one using constraint-based modeling techniques, the other based on satisfiability testing.

The Computing with Language stream saw the start of an NWO-funded project, called 'Derive!', which is aimed at bringing recent advances in natural language processing and computational logic to bear on information extraction and retrieval; it addresses the problem of finding content in natural language documents. Christof Monz is the principal investigator on this project. At the same time, Monz and de Rijke worked on the use of shallow or light-weight natural language processing tools for the generation of back-of-the-book indexes; a prototype has been developed and is currently being set up by Bergo as the core of an experimental system, where domain-dependent knowledge is being acquired to aid in further improving the behavior of the system. Aiello, Monz, and Todoran (ISIS, UvA) explored combinations of natural language processing tools and spatial information for understanding the structure and content of scanned documents.

The group's activities in the Computing with Information stream ranges from fundamental to experimental to applied. In 1999 a project on semistructured content was started, with funding from the British Council; the core idea of the project is to apply a modal logic perspective to specifying and constraining the graph-based datamodels underlying semistructured content; results obtained so far by Alechina and de Rijke include significantly lower complexity bounds for some common reasoning tasks, and improved algorithms to perform these tasks. Aiello, Areces and de Rijke worked on accessing *visual content*; they proposed a calculus aimed at enhancing image retrieval with the ability to perform spatial reasoning using 'expensive' picture descriptions (common in content based image retrieval systems. In collaboration with Chidlovskii (Xerox), Ragetli and de Rijke worked on automatically generating information extractors for identifying relevant content in result pages of web-based search engines. And together with van Eijck they are studying the use of glossary-based navigation tools for exploring and organizing the contents of electronic handbooks; this work is part of the Logic and Language Links project funded by Elsevier Science which was started up during the second half of the year.

Fuzzy Logic and the Logic of Perceptions



Lotfi A. Zadeh, father of the fuzzy logic, is professor at the Department of Electrical Engineering and Computer Sciences of the University of California. In December 1999 he visited ILLC to deliver a lecture on a Logic of Perceptions.

The Institute for Logic, Language and Computation (ILLC) is widely acknowledged to be a leading center of research and instruction in its field. To see what is happening on the frontiers of logic, one should pay a visit to ILLC and exchange views with members of the faculty and student body.

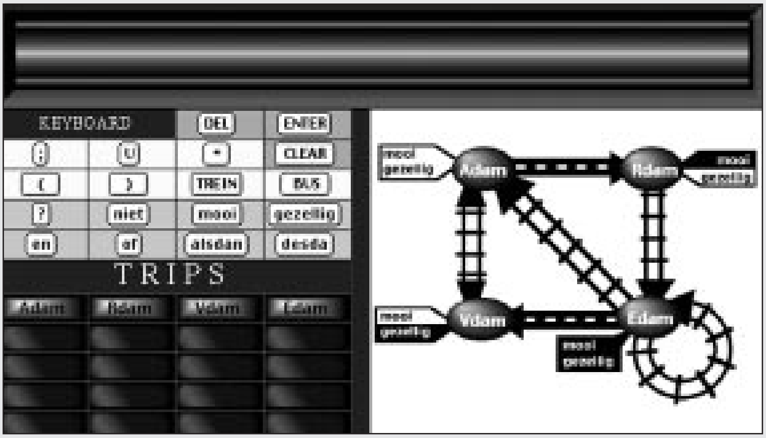
It is not surprising to me that fuzzy logic (FL) has not been and is not a focus of attention of ILLC. By and large, the logic community has taken a skeptical view of fuzzy logic, reflecting many misconceptions about fuzzy logic and its relationships with multivalued logic and probability theory. The recently published treatises on fuzzy logic by Hajek, Novak and Perfileva, Reghis and Roventa, Turunen and others should go a long way toward clarifying the misconceptions, firming the foundations and charting the course for further research.

One of the misconceptions about fuzzy logic is that it is very closely related to multivalued logic (MVL). A point in common is that in both FL and MVL, truth is a matter of degree. However, in FL everything, including truth, is - or is allowed to be - a matter of degree. To illustrate, in MVL there are only two quantifiers, universal and existential. In FL, quantifiers play the role of absolute or relative counts or measures, and, in general, are represented as fuzzy numbers.

A major difference between FL and MVL is centered on the concept of granularity or granulation. Thus, in FL everything has - or is allowed to have - a granular structure, with the understanding that a granule is a clump of points (objects) which are drawn together by indistinguishability, similarity, proximity or functionality. Granularity reflects a fundamental limitation on the cognitive ability of humans to resolve detail and store information. Most of the practical applications of fuzzy logic involve a confluence of fuzziness and granularity. It is this confluence that underlies the basic concept of a linguistic variable in fuzzy logic, and differentiates FL from MVL.

A recent and important development in fuzzy logic is the emergence of what may be called the Logic of Perceptions (LP). I would be delighted if the logic of perceptions struck a resonant chord at ILLC.

Lotfi Zadeh



Dissemination of Logic

Dissemination of logic is concerned with promoting logic and its applications, both within academia and outside the university. This is done by means of courses where logic, broadly perceived, infuses disciplines like programming, natural language analysis, cognition, and philosophy of language, and by means of the development of course material for secondary schools, suitably enhanced with multimedia support. Further extra-curricular activities such as lectures, newspaper articles, books and software for the general public, etc. are meant to exert an influence on society at large.

Our efforts to promote a florishing logic education remain closely linked to the pursuit of research goals which are carried by a national research community. Using active research in logic as a permanent source of inspiration we aim to disseminate the living essence of the subject.

Logic and Language Analysis
Important themes in the analysis of natural language analysis are concerned with the dynamics of interpretation and of inference processes. Rule systems that pay due attention to these themes may involve considerable departures from standard rule systems, since they, for instance, may lack the property of monotonicity. If one adds a premise to a given premises list, one runs the risk of destroying argumentative patterns, and may no longer be able to derive conclusions that were derivable before. Developing sound and complete calculi for dynamic anaphora logics, a calculus for 'variable free' incremental semantics emerged which proved to be a suitable basis for a new version of Montague

grammar. The findings were incorporated in a course on Computational Semantics that bridges the gap between natural language and programming language semantics, thus demonstrating the continuum of imperative and functional programming and natural language understanding.

Logic and Programming

In dynamic variations on predicate logic formulas are interpreted as actions with a suggestion of execution processes. However, formulas of 'dynamic' predicate logic are not suited for execution on a computer as they stand, for particular actions (existential quantification) tend to lead to infinities of possibilities that would embarrass even the most powerful computer.

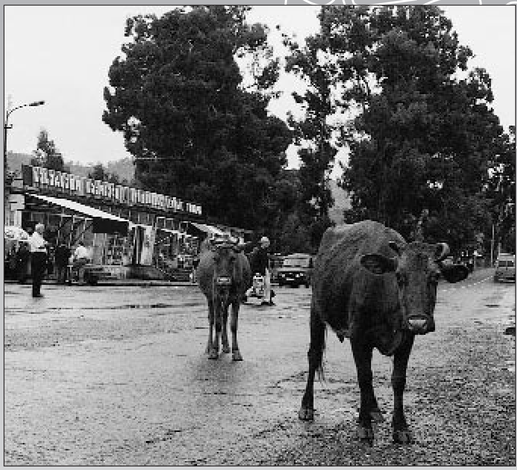
By an ingenious computational reinterpretation, dynamic predicate logic may figure as the basis of a programming language after all. A language *Dynamo*, has been developed that implements an executable process interpretation of dynamic predicate logic, with constructs for bounded iteration and bounded choice. Dynamo owes its inspiration and computational thrust to Alma, a language developed by Krzysztof Apt and his co-workers, and it forges a link between the Amsterdam research traditions in dynamic and computational logic. Further work includes an improved execution mechanism, where tests that cannot be performed immediately are stored to be resolved at a later stage. Heguiabehere is implementing the resulting system with constraint handling. Further information can be found at *www.cwi.nl/~jve/dynamo*

Logic and programming are also brought together in courseware developed in the area of reasoning and imperative programming. The undergraduate course material prepared by Van Benthem, Van Eijck, Jaspars and Kaldewaij forms the starting point for the preparation of a series of booklets with internet software for use in secondary schools. Amsterdam University Press and CWI are involved in the plans.

Logic and Games

Marc Pauly established further connections between game logic, a generalization of propositional dynamic logic, and modal logic. 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. Tools are developed for the graphical display of evaluation games for dynamic logic formulas in Kripke models. Furthermore, progress has been made with axiomatization, decidability and expressiveness and we are presently working on an implementation of Parikh's games and on a logic for coalition games.

ILLC goes Caucasia



With the financial support of, among others, the Spinoza project, the ILLC in Amsterdam has started to support kindred colleagues in Tbilisi, the capital of Georgia in order to help build up academic life. From 1997 on we have sent books, bought equipment and helped with network facilities. We have set up homepages for the groups and we have got three Georgian students over here for a one year logic program. Most importantly, we (Paul Dekker, Ingrid van Loon and Dick de Jongh) took over the organization of the Third Tbilisi Symposium on Language, Logic and Computation, held in Batumi in September 1999. As a consequence, an ILLC-delegation of eight men and women left for Batumi where the Symposium was held.

It was a heavy journey, through a country a stone's throw from Chechnya, Dagestan and Nagorno-Karabagh, but, as expected, the journey was worth its salt. The trip went through Mtskheta, the former capital of Georgia, with religious architecture of the Middle Ages, Gori, the place of birth of Joseph Dzhugashvili (aka. Stalin), Colchis, where Jason and the Argonauts got the Golden Fleece, and Zestafoni, the place of birth of the prominent Georgian logician Shalva Pkhakhadze. In that place, too, the first of the overwhelming Georgian banquets took place, with the delicious Georgian wine, the tamadas, singing, dancing, toasting. The remainder of the trip passed by almost unnoticed....

Also professionally, the five-day symposium was as heavy and rewarding as the journey. Three tutorials were given for the benefit of local students, although these were also frequented by many local and foreign researchers. Leading scientists from Moscow up to Montreal gave invited lectures and the programme also included parallel sessions with papers contributed by Georgians and visitors from abroad. Thus, Georgian participants profited from the work presented by representatives of the international community, and, in return, the Symposium provided a platform for the presentation of their own work.

Everyone who has experienced Georgian hospitality knows it's proverbial, like one who has tasted Georgian wine necessarily wants more. Add to that impressive scenery, mountains and plains, a very old and intriguing culture, architecture, religion and language, and one can be sure that you can find us actively present at the next Symposium in 2001.

Paul Dekker
Ingrid van Loon

A joint initiative with the Logic in Communication group was the formation of a reading group on Game Theory and the organization of a two day workshop Logic and Games. The workshop provided a platform for the presentation of recent work in this area and attracted researchers from various countries and from a wide variety of disciplines (mathematics, linguistics, economics, philosophy, social sciences).

Structuring Information Flow in Electronic Handbooks
A concrete application of theoretical ideas on information structuring is the analysis and prototyping of an electronic environment for scientific handbook information, with Van Benthem and Ter Meulen (eds.), Handbook of Logic and Language, Elsevier 1997, as the concrete focus. This joint project with Elsevier Science BV aims at designing formats for electronic dissemination of knowledge as traditionally found in scientific handbooks. Jon Ragetli has started working on this LoLaLi project as a Ph.D. student in September 1999.

Implementation of Tools and Animation Programs
Innovation in logic education is pursued by means of implementations illustrating abstract definitions. Theoretical points with a boring flavour get a vivid appeal when they are illustrated by appropriate animations. Abstract definitions of reduction strategies in lambda calculus are conveniently demonstrated by means of procedures that actually perform these reductions and by means of working implementations of language fragments semantic programming come to life. For purposes of course rejuvenation, the toy imperative programming languages from the semantics textbooks have been implemented in Haskell (a state-of-the-art functional programming language eminently suited for fast prototyping): WHILE (imperative programs without procedures) and PROC (imperative programs with procedures, with static and dynamic procedure calling mechanisms, and static and dynamic binding of local variable declarations).

Visualization is a key method in communicating logic in an electronic environment, as can be seen from the success of Tarski's World and Turing's World, developed by Barwise and Etchemendy and their team from Stanford University. In a similar vein, the Logic in Action group developed calculators and animations for use in several elementary logic courses, freely distributed over the internet. A sample of such web-applications can be found at *http://turing.wins.uva.nl/~jaspars/animations/*

Section 4 Guest column by Sergei Artemov

Sergei Artemov is a professor of mathematics at the Steklov Institute and Moscow University, where he heads the group of logicians that continue the tradition of Kolmogorov and Markov. He is also a visiting professor of mathematics and computer science at Cornell University, where he is involved with various applications of logical proof theory to computation. Artemov's contacts with ILLC and The Netherlands are of long standing, including provability logic and logical foundations of grammars. Despite his international visibility, not many people know that he is also an active ice-hockey player. In 1999 he was the Spinoza lecturer at ESSLLI

The logician Kurt Gödel was recently designated greatest mathematician of this century by TIME magazine for his famous Incompleteness Theorem of 1931. This theorem revealed a paradoxical side of mathematical provability. Any formal system that attempts to capture all the truths of mathematics in a finite set of axioms and rules must be incomplete, and cannot even establish its own consistency.

The Incompleteness Theorem is a classical result of the field, taught in many courses the world over. Its fine-structure has been studied by many logicians, and many follow-up results have clarified our understanding of Gödel's insights. Over the past decade, my own research has been concerned with the following aspect of Gödel's analysis of proofs. Gödel showed that not all mathematical truths are provable in any given formal system. Logicians have then analysed this notion of 'provability', and managed to determine its general properties (incidentally, Dick de Jongh in Amsterdam, and Albert Visser in Utrecht are well-known contributors). But 'provability' is the statement that some proof exists for a given theorem: what remains open is the complete logic of proofs as objects in their own right. My question has been (following a largely unknown attempt by Gödel himself from the thirties): what is the complete basic calculus of proofs as such that underlies Gödel's arguments?

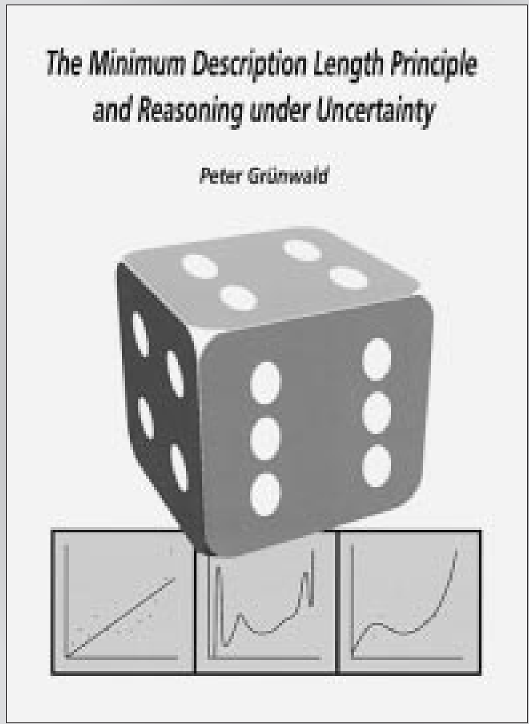
In my Spinoza lecture, I presented the solution anticipated by Gödel. This takes the form of a constructive calculus of computable proof terms, having key operations of 'putting together', 'choice', and perhaps most intriguing: 'proof checking'. I proved completeness of this new calculus w.r.t. Gödel's intended interpretation, via an argument whose technical intricacies I spare you in this column. Moreover, I showed how this system generalizes earlier analyses of proofs, such as the famous Curry-Howard isomorphism in lambda calculus (beloved by Dutch type theorists and researchers in formal grammars). Likewise, this calculus throws new light on constructive logics (such as Brouwer's intuitionism) and modal or epistemic logics such as Gödel's modal provability calculus. Johan van Benthem once argued for the systematic introduction of proofs as good reasons in logics of knowledge (knowledge is something that you have 'good reasons' for), in order to overcome current limitations of that field. Such an extension of the framework is precisely what my calculus provides.

My current interests lie more on the computational side. The traditional theory of formal program verification contains an annoying foundational loophole: verification of a verificator is impossible. Recently, I have been able to show how one can get around 'Gödel's incompleteness curse' here, by using my logic of proofs. I take all this to mean that classical problems in the foundations of mathematics are very much alive, generating new fundamental insights as well as practical applications.

'I enjoyed discussions at the Summer School. ... I was impressed by the great range, across many disciplines, of the lecturers, given how specialized many scientific meetings are. It was a pleasure to be present at one of such intellectual breadth.'

Patrick Suppes,
Vienna Circle lecturer
ESSLLI

FoLLI Dissertation prize



The FoLLI Prize Committee has awarded the 1999 FoLLI Prize for Outstanding Dissertation in Language, Logic and Computation to Peter Grünwald for his dissertation 'The Minimum Description Method and Reasoning Under Uncertainty'. The prize is co-sponsored by Logic in Action. Larry Moss, member of the Prize Committee, explains why the prize is awarded to Peter Grünwald.

Last summer, while the FoLLI Prize Committee was nearing the completion of its deliberations, I happened to see that the Psychology Department at my university was having a one-day meeting with talks on the subject of mathematical models in psychology. I was intrigued to see that one of the speakers was Peter Grünwald, whom I had heard of in connection with the prize. From the little that I knew of his dissertation at that point, I was not amazed that Peter had received invitations from mathematically-oriented psychologists and cognitive scientists. But I was pleasantly surprised to see that my colleagues were interested in something from a field quite different from their own.

Grünwald's dissertation is an exploration of the Minimum Description Length (MDL) principle. The fundamental idea behind the MDL Principle is that any regularity in a given set of data can be used to compress the data, and describe it using fewer symbols. In this respect MDL is a way of approaching the problem of Inductive Inference, and its more recent computer science variation, Machine Learning. This problem of inferring general patterns and principles from particular instances is a crucial concern all over science, and yet from the dissertation I get the feeling that rather little has been done on it. For example, the logical *tradition is normally concerned with the workings of regularities, not with their discovery and discard. MDL shows itself to be much more useful in practical settings than its intellectual ancestor, Kolmogorov Complexity.*

The dissertation explains what MDL is in detail, it gives several different but equivalent formulations and it also offers reasons for using MDL. This matter is delicate, for the MDL principle generally seeks a balance between the complexity of a description and it's error rate and often predicts models for data which are too simple. A defense of the principle will have to explain this. Roughly speaking, Grünwald's explanation is that the overly simple models are usually 'safe' or 'reliable' even if they are 'wrong.' Of course, all of my scare quotes allude to long and technical discussions. Grünwald states and proves several theorems showing when and how too simple models can be used in a certain 'reliable' fashion when it is used to predict future data. The dissertation changes theme in Part II to consider experiments with MDL, perhaps for the first time, done with researchers in Finland. MDL is compared with other methods of inductive inference. The last part of the dissertation, part III, is on reasoning under uncertainty, a subfield of artificial intelligence Grünwald proposes. This part in a sense is a different piece of work.

This dissertation should have an appeal to a broad range of people, as befits the winner of this FoLLI prize. Obviously, it will be a standard reference for those already working in the area of MDL. And equally obviously, it should be attractive for people interested in foundations of statistics. One of its themes is that probability distributions correspond to methods of description. This is a fundamental connection that goes via coding theory and considerations of entropy. Yet another source of interest will come from people interested in reasoning under uncertainty. My cognitive science friends are excited by the work because it offers a strong approach to the problem of deciding between psychological models. They were interested enough to hear about it, despite what one called 'the unfamiliar mathematics' of it. I can see why they are interested, and why they may be busy for a long time. Above all else, we should be pleased that work which we value is also valued by other research communities.

Larry Moss

Section 5 LOGIC IN INTERACTION

The Logic in Action participants enjoy a promiscuous life, professionally speaking, witnessing rich and intensive contacts with individuals and groups in the Netherlands, Europe and other continents, which have given rise to many collaborative efforts. Part of the Spinoza resources are also spent on individual visitors, as well as workshops and conferences that create new scientific alliances.

Logic Actions in Amsterdam

INSTITUTE FOR LOGIC,
LANGUAGE AND COMPUTATION

First of all, this Spinoza project could not function without its embedding in the stimulating academic environment provided by the *Institute for Logic, Language and Computation* (ILLC) of the University of Amsterdam. The institute was founded to further the scientific and logical study of the structure, modification and transmission of information. The ILLC is an interdisciplinary research institute, in which groups from the faculties of Mathematics, Humanities and Social Sciences, participate and engage in collaborative research and education:

- Logic and Theoretical Computer Science, Faculty of Mathematics, Computer Science, Physics and Astronomy (WINS)
- Applied Logic Lab, Faculty of Social Sciences
- Philosophy of Language and Philosophical Logic, Faculty of Humanities.
- Computational Linguistics, Faculty of Humanities

For further information about ILLC, one can consult the home page at: *www.illc.uva.nl*

Logic Actions in The Netherlands

The national habitat of the Spinoza project is the Dutch Graduate School in Logic (OZSL). The aim of the OZSL is to guide the development of logic research in the Netherlands and to make sure that the Netherlands will continue to play a prominent role in the field. The OZSL brings together mathematicians, computer scientists, cognitive scientists, linguists, and philosophers from Amsterdam, Delft, Eindhoven, Groningen, Nijmegen, Tilburg and Utrecht.

Further information about OzsL can be found at: *www.ozsl.uva.nl*

Logic Actions in Europe

In Europe the main institutional environment for the *Logic in Action* project is the European Association for Logic, Language and Information (FoLLI). FoLLI was founded in 1991 to advance research and education on the interfaces between logic, linguistics, computer science and cognitive science and related disciplines in Europe. FoLLI 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).

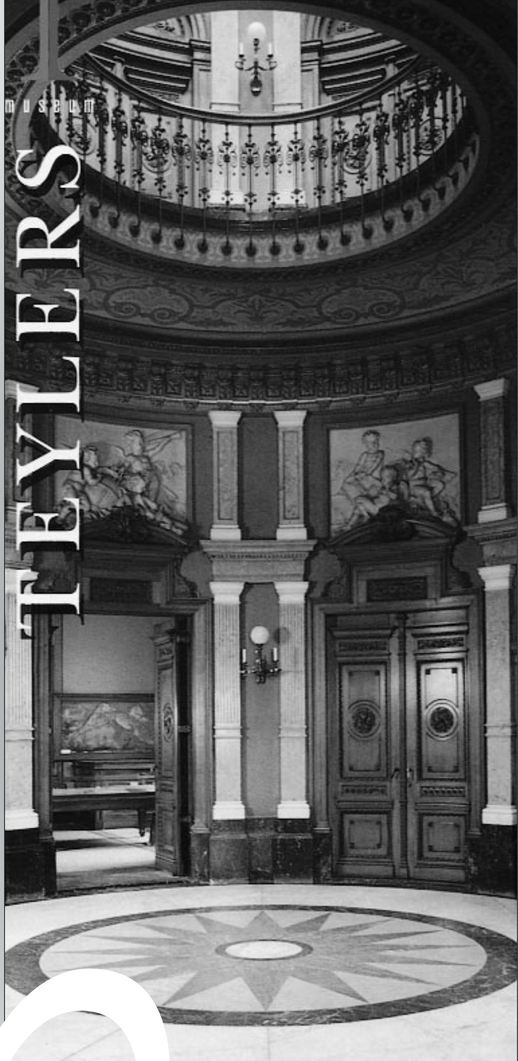
Logic in Action played a supporting role at all levels of the last two Summer Schools in Saarbrücken (1998) and Utrecht (1999). Students can apply for a grant to participate, *Logic in Action* sponsors the annual Spinoza Lecture (see page 32), and, moreover, project leaders are involved in lecturing and organization. *Logic in Action* also provides all OZSL Ph.D. students free membership of FoLLI, including subscription to the *Journal of Logic, Language and Information.*

Further information about FoLLI can be found at: *www.folli.uva.nl*

The project participants furthermore collaborate actively with several research groups in Europe. At the following map of Europe, we have indicated what our main contacts have been:

Special mention deserve the groups in London, Manchester and Saarbrücken, with whom there has been intensive collaborative research on modal and algebraic logic. Among other things this has lead to a text-book on Modal Logic with two of the project leaders as co-author.

Johan van Benthem's 50th anniversary



One of the projects planned for 1999 was the fiftieth birthday of Johan van Benthem. It was generally felt that something should be organised, and quickly decided that – to start with – a festschrift was to be produced. With exceptional figures simple tasks become exceptional. After sending two emails over a hundred scientists agreed to prepare an article for this book. The editors didn't expect such an overwhelming response and already in the first email promised every cooperating author a free copy of this birthday present.

The prospective authors were wiser. Apparently everyone thought this was an offer which could not be refused. Instead of receiving 50 offprints of your own article – the usual bribe – one could obtain a book containing hundreds of them. Surely van Benthem has that many friends, they should have argued. Moreover, the multidisciplinary nature of van Benthem's research would guarantee a volume with a plethora of interesting contributions from many different fields. The editors became scared. Keeping their promise while not bankrupting the ILLC would mean a reduction of the page limit to exactly one page per author. Luckily words can be carried by other media as well these days. They decided to publish the liber as a CD ROM, now available from Amsterdam University Press.

A party had to be organised, too, but the editors, a bit wiser by now, did not dare to arrange an event by themselves. Luckily van Benthem was scheduled to give an evening lecture at last years ESSLLI summer school in Utrecht and that venue was chosen. Only when he was told that his speech could only take 30 minutes, he started getting suspicious. With a show featuring among others Dov Gabbay and Peter van de Emde Boas the evening was a great success. A few months later van Benthem showed the youngsters how such events are organised. He in turn invited the Dutch contributors and other friends and colleagues from the logic community to share his love for the enchanting collection of Teyler's museum in Haarlem. The two main rooms constituted a beautiful metaphor for van Benthem's view on science: The first room contains an amazing collection of data from natural history, leading to the second which shows a collection of superb technological achievements. Among fossils of other mastodons van Benthem revealed his vision on the future of logic. In accord with his recent interest in games we wish him a playful second half of his life.

Maarten Marx

Logic Actions Worldwide

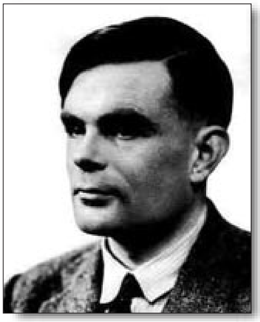
Outside of Europe, the main contacts of the *Logic in Action* project can be found in the United States, but not exclusively, as the following map shows:

Stanford deserves to be mentioned especially. The Center for the Study of Language and Information from Stanford University is a sister institute of the ILLC, and Johan van Benthem, holding the Bonsall visiting chair of humanities, spends his spring quarters there.

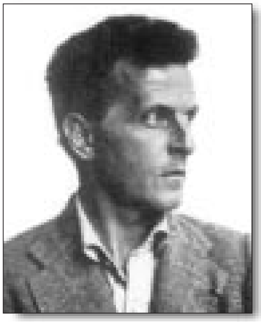
Epilogue WHICH WAY THE PROMISED LAND?

TIME magazine recently published a list with ‘the 20 most important intellectuals of this century’. Two of these twenty were logicians working at interfaces with mathematics and computer science: Kurt Gödel and Alan Turing, while a third was a philosopher deeply into logic and language: Ludwig Wittgenstein. Whatever one thinks about hit-parades, the fact is impressive evidence of cultural influence, especially considering that TIME included no straight mathematicians, linguists, or computer scientists. (It does list the inventor of Internet, but he was a CERN physicist.) So is ILLC research secure and prosperous, in the Promised Land to which these great pioneers from the golden thirties guided us? The second fifty years of logic in this century has in fact been described as the development of ‘fine structure’ within the contours discovered by the above thinkers, and others of the same calibre, such as Luitzen Brouwer and Alfred Tarski. This makes historical sense: great ideas often demonstrate their greatness only after an era of development and consolidation.

KURT GÖDEL



ALAN TURING



LUDWIG WITTGENSTEIN

Unfortunately, however, much research gradually becomes consolidated in details: with ever-growing technical ingenuity for experts, but without the original revolutionary fire, or vision of the larger issues. Still, I believe that the rationale of publicly subsidized science is not high-flying ingenuity for the cognoscenti, but great issues of clear importance. This importance need not be directly practical, but may relate to cultural values too. In my view, a profession should regularly reflect on these issues. I am often struck by the conservatism of specialist agendas, high-lighted by the stock themes and sometimes even the lay-out of standard journal articles. The ‘tricks’ which everybody learns are remarkably uniform.

What are the great research questions which drive logicians A.D. 2000? More personally: which burning intellectual issues exercise you, other than: ‘how do I add an epsilon to my specialism’, or ‘how to be a delta cleverer than my close colleagues’? And are the guiding questions now the same as those which motivated Gödel, Turing, and Wittgenstein?

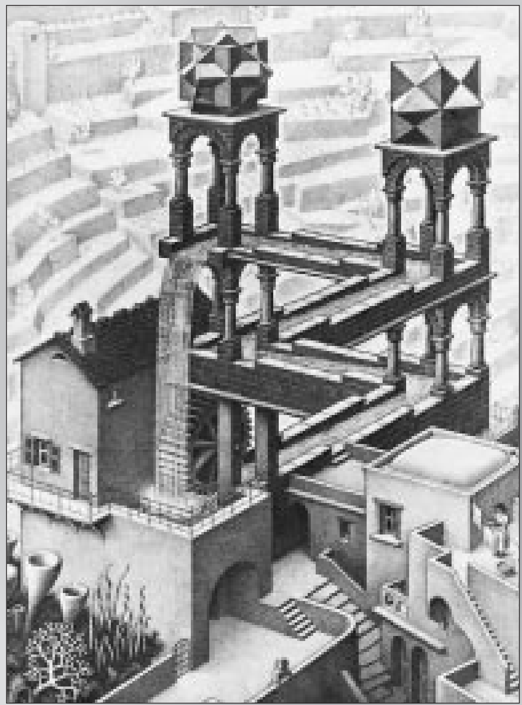
I myself do not think so. At the close of the century, we are faced with new intellectual phenomena and problems which simply did not occur on the agenda of the Founding Fathers. The initial emphasis on the foundations of mathematics and philosophy has fallen away, and logic finds itself in a scientific environment where the main themes are the nature of information and cognition. The Grand Challenges here are different from what they used to be. Just consider this empirical miracle: how is it that people are so successful in handling higher cognitive tasks - of which reasoning (no matter how broadly interpreted) is just one - and what does logic have to say about asserting, asking, learning, reading, and related activities, of individuals and groups? Or take a more theoretical theme: how is our favourite logico-semantical concept of information connected with that of physical or algorithmic information theory, and can we achieve a unification here? Finally, in realistic applications, ‘logic meets bulk’. Logical systems pursue maximum simplicity in axioms and rules, but they function in a world of information and cognition full of complexity. What can logic say about the Great Mass of information carriers in language, writing, or internet, which requires entirely new concepts of architecture on intermediate levels?

In this context the focus of logic changes in various ways. First, the perspective changes: from purely methodical themes to real phenomena. Not only: what is a ‘proof’ in some Platonic heaven, or as an idealized mental construction, but also: how does high-level and low-level argumentation proceed in reality? Obviously we approach this in an exact manner, and so usually with mathematical models, but these are not an end in themselves but a means to a better understanding, and at times better practice, of the phenomena. In doing so violate Gottlob Frege’s ban on ‘psychologism’, the supposedly ‘ill-conceived’ realistic interpretation of logical entities. In my view, Frege’s excommunication has become infertile and narrow-minded. Next, I see another change of habit, from reflection to action. Logical methods not only help us to understand the world but also change it, for instance, by creating new langauges and reasoning/computation styles in computer science and AI. In this way the quality of research can be measured, not only by its understanding existing phenomena, but also by the creation of new ones, which did not exist in the past.

Given this shift from internal to external focus, who are our closest scientific neighbours? The ILLC believes it is extremely broad-minded, having not only working contacts with the old mathematical and philosophical fraternities but also, since two decades, with linguists and computer scientists. But information and cognition are equally the domain of statisticians, psychologists, physicists, neurologists, and biologists and this list is not even exhaustive. The logical community is still rather confined, and could open up considerably in terms of inspiration and outward appeal. Would we still have much of importance to offer in such a broad scientific environment? I believe so, providing we recognize the broad outlines in logical research, and keep the smaller issues in proportion.

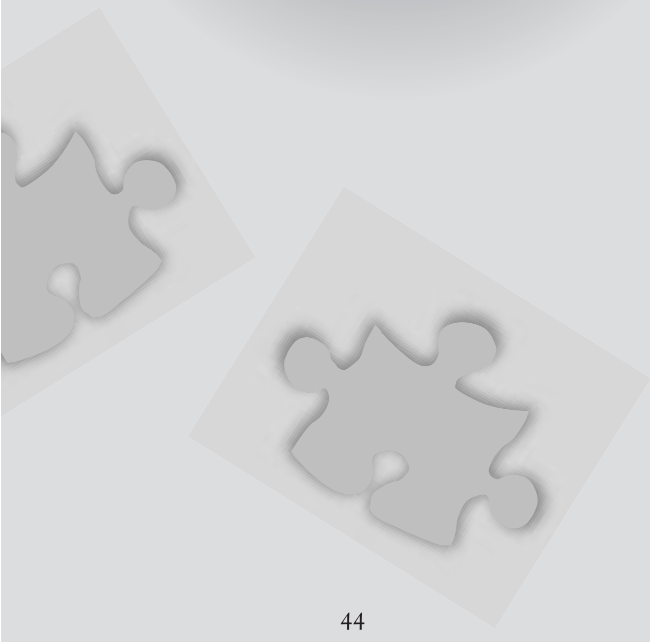
Johan van Benthem

Dangerous knowledge and self fulfilling



The received formal-theoretical outlook upon communication is of a rather boring nature. An agent, typically called a, communicates a proposition p and a second agent, b, acknowledges receipt of the proposition and adds it to his stock of beliefs. Equally typically, if agent a was right about p, then b is now, too. Simple enough, or not? Spinoza researchers Alexandru Baltag and Annette Bleeker tell us about a few of the more mundane situations of information exchange, which they study in the Logic in Communication project.

Consider two persons, Alice and Bob, who are having a relationship. They commonly believe that they don't cheat on each other, till Alice starts out an affair with Charles. As Charles is a bit worried about Bob, Alice emails him: 'Don't worry, Bob doesn't know about us'. Accidentally (or less accidentally) Bob sees this message. Paradoxically enough, after seeing the message, which says that Bob doesn't know about the affair, Bob knows. Reading the message is a way to falsify it. (A remote variant of this one allows you to deliberately nail your most detested opponent, let's call him 'Gargantua'. Here it goes: 'Everybody except Gargantua can consistently assert this sentence.' Try it out on your friends, everybody can consistently, even truthfully, assert the sentence – except Gargantua, that is.)



Information may flow in other unexpected forms. A laboratory case is that of the so-called muddy children. These are 4 logically well-trained children, exactly 3 of which have dirt on their faces. Each can see the faces of the others, but doesn't see his or her own face. Now the father comes in and announces 'At least one of you is dirty'. Surely, this was already known to everybody, and the children do not seem to learn

suspicions logics for insecure communication

anything new from it. Or do they? Indeed, for what each child used to know in private, that there are dirty children, is public knowledge now.

The story doesn't end here, because it is only a leg up to a more curious game in which the father starts asking the kids, over and over again: 'Do you know if you are dirty or not?' and after each question the children answer openly, decently and truthfully. Given that the father already knows the true answers before he gets them, would you think this language game yields any new information? Not to the father, but the well-trained children benefit from hearing what the others say. After a couple of rounds, all dirty children know they are dirty and after they have replied affirmatively: 'Yes, I know I am dirty' the clean kid knows she's clean. Smart kids.

Sometimes language is like encryption. In the case of the muddy children, it seems epistemic logic provides the key to decode the exchanged information. Better known keys are provided in the field of cryptography, which also raises puzzling questions. If someone sees an encrypted message, without having the key to decrypt it, seeing the message is learning that what you see is not the message. And what about public-key cryptography: the secrecy of a message can be kept by making the key public, doesn't that sound paradoxical? And what does one actually learn when one learns a key? Every key is just a number, and any number is a number which you knew existed. Sure, you can try and decrypt encrypted messages with a key, but for this you try out any number. What's the good news?

In our on-going work, we are trying to understand the flow of information (and misinformation) in situations like the ones described above. All of the above examples deal with belief-changing actions or processes featuring both private and public acts. How can one represent the hidden structure of such epistemic actions? How does one player's beliefs and suspicions about the others affect her strategy and the outcomes of a game? How can we understand, from a logical and epistemic point of view, self-fulfilling beliefs or self-defeating ones, deceiving knowledge and instructive lies, insecure secrecy and fully-secure public keys? Think about it! At least that's what we do most of the time.

Annette Bleeker
Alexandru Baltag

Studying logic in Amsterdam

Shai Berger (Israel) and Jason Mattausch (USA) are two of the international MSc students at ILLC. They were awarded a Spinoza scholarship for the 1999/2000 academic year.

In Dirk Gentley's Holistic Detective Agency, sci-fi parody writer Douglas Adams introduces an investigator who believes in the inter-relatedness of all things.
I think someone in Amsterdam must have been convinced, at least as far as the inter-relatedness of all things logical and cognitive goes... Coming from Computer Science, I have always wanted to study the human mind and its reasoning mechanisms, with the hope that these could be modeled on a computer. This lead me to take interest in Cognitive Psychology, Philosophy and Linguistics, but I found very little interaction between these different subjects. The methods and approaches of Mathematics and Computer Science were rarely applied to the problems dealt with in other disciplines. Things changed drastically, however, when I came to the ILLC

In Amsterdam I found, for example, that I could try and apply ideas from Proof Theory to problems in Philosophy of Mind, and my programming experience to research in Visual Reasoning. My studies in the faculty of humanities now also inspire my mathematical work directly, and this has never happened to me before. I dare say that this integration of subjects is not incidental, and that it is not caused by my personal interests and dispositions. It is brought about by a system of interdisciplinary events and common activities where people from different fields meet to share ideas and attitudes.

This brings me to another notion from Dirk Gentley, that of Zen Navigation: If you don't know how to get somewhere, find someone who seems to know where they're going, and follow them; you might not come to where you wanted to go, but you'll probably get to somewhere interesting. I find this a very adequate description of the early stages of an academic career. The only difference is that in physical navigation, you can only follow one person; in a place like Amsterdam, you can follow quite a few, and in radically different directions.

Shai Berger

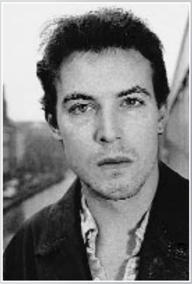
After four years of undergraduate work at the University of California, Los Angeles, in both linguistics and philosophy, I sought a graduate program in which I would retain the ability to pursue interests in both fields. I would like to do so in a place where the education I received would come 'first hand'. There ought to be opportunities to participate in courses, seminars, and so on with linguists, philosophers, and others who were presenting their own work and work of those within the immediate professional vicinity.

In an institution in which many of the faculty present work which they themselves are responsible for, one of the greatest potential disadvantages for a student is that one may often expect to lose the opportunity to see the various sides of a many-sided issue and instead see merely one. But those I have encountered in the ILLC program, and, I think, to a large degree the Dutch in general, take incredible care to shape their perspectives in a way that is based on comparison and synthesis, attempting to harmonize these approaches in a way which will not only offer an answer to the particular

Appendix 1. Events, guests

The following events have been (co-)organized and/or sponsored by (members of) the Spinoza poject:

- Lecture day on Co-algebras and Modal Logic; Amsterdam; February 18
- Workshop on Dynamic Semantics; Dagstuhl, Germany; January 31 - February 3
- Groningen - Amsterdam exchange day of talks; Groningen; February 26
- Methods for Modalities (M4M); Amsterdam; May 6 -7
- Workshop on Modal Logics of Space; Amsterdam; May 10
- Modal Logic Meeting; Amsterdam; June 14 - 15
- Logic Colloquium; Utrecht; August 1 -6
- ESSLLI; Utrecht; August 9 - 20
  Financial support:
  - Spinoza lecture by Sergei Artemov (see also page 32)
  - Vienna Circle lecture by Patrick Suppes
  - sponsoring of two Stanford students
  Courses/Lectures:
  - Johan van Benthem
  - Paul Dekker
  - Jan van Eijck
  - Maarten de Rijke
- First Workshop on Inference in Computational Semantics (ICoS-1); Amsterdam; August 15;
- The Third International Tbilisi Symposium on Language, Logic and Computation; Batumi, Georgia; September 12 - 16
  For a personal impression, see page 30



question at hand, but also represent what was right (and wrong) with the various unsuccessful approaches of the past.

It is likely that anyone who has found himself reading this publication is already well aware of Amsterdam's deep tradition in analytic sciences and the strong reputation of contemporary linguists, mathematicians, and philosophers throughout Holland. If the Netherlands hold a tradition which feeds the strength of the ILLC program most generously, it is the remarkable tendency toward creative resolution of obstacles or outright conflict. The mere existence of the ILLC can be said to be the product of the effort of the Dutch and her academic institutions to recognize unity among certain divergent disciplines, such as, for example: linguistics, philosophy, and mathematics. The unity may, really, always have been present, but it has often and in many ways been neglected without good reason.

Jason Mattausch

- Aachen-Amsterdam Exchange; Amsterdam: February 19 and Aachen: November 5
- Workshop on Logic and Games; Amsterdam; November 19 - 20
- First Southern African Summer School on Logic, Universal Algebra, and Theoretical Computer Science (LUATCS99); December 1 - 9
- ILLC alumni event; Amsterdam; December 17
- 12th Amsterdam Colloquium (AC99); Amsterdam; December 18 - 21
  For a report, see page 15
- Computational Logic Seminar, January-December; weekly

Guests

Spinoza sponsored the visits of the following international guests:

- Natasha Alechina, University of Nottingham
- Philippe Balbiani, Laboratoire d'Informatique de Paris Nord
- David Basin, University of Freiburg
- Patrick Blackburn, University of Saarlandes
- Johan Bos, University of Saarlandes
- Luis Farinas del Cerro, Université Paul Sabatier
- Volker Haarslev, University of Hamburg
- Ian Horrocks, University of Manchester
- Natascha Kurtonina, University of Pennsylvania
- Oliver Lemon, University of Dublin
- Viktor Selivanov, Novosibirsk University
- Rohit Parikh, New York University
- Zdzislaw Pawlak, Polish Academy of Sciences
- Ian Pratt, Manchester University
- Steve Pulman, SRI International Cambridge, Computer Science Research Centre
- Ariel Rubinstein (Tel Aviv and Princeton University)
- Gabriel Sandu (University of Helsinki)
- Renate Schmidt, Manchester Metropolitan University
- Roberto Sebastiani, University of Trento
- Matthew Stone, Rutgers University
- Lotfi Zadeh, University of California

Appendix 2. Photo Gallery: our people

Marco Aiello

(Ph.D. student, spatial reasoning, vision, image processing and internet technology)

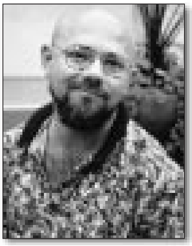
Carlos Areces

(Ph.D. student, theory and applications of restricted description languages)

NOT ON PICTURE

Krzysztof Apt

(professor, Logic Programming, Constraints, Program Verification); not on picture



Alexandru Baltag

(postdoc, co-algebra and modal logics)

Johan van Benthem

(project leader)

Alexander Bergo

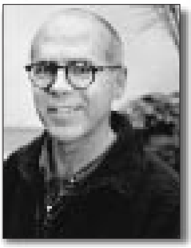
(MSc student, use of NLP tools in traditional IR tasks)

Annette Bleeker

(Ph.D. student, encrypted message passing)

Paul Dekker

(project leader 'Logic in Communication')



Jan van Eijck

(project leader 'Dissemination of Logic')

NOT ON PICTURE

Rosella Gennari

(Ph.D. student, constraints and computing with modal logic); not on picture

Jelle Gerbrandy

(post-doc, epistemic dynamic logic)

Juan Heguiabehere

(Ph.D. student, computing with dynamic semantics)

NOT ON PICTURE

Lex Hendriks

(post-doc, computational logic); not on picture

Jan Jaspars

(free-lance logician, applications of modal logic)

Gwen Kerdiles

(Ph.D. student, conceptual graphs)

Ingrid van Loon

(project administrator)

Maarten Marx

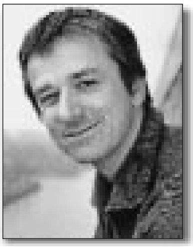
(post-doc, modal logic)

Christof Monz

(Ph.D. student, information retrieval and extraction)

Hans de Nivelle

(post-doc, theorem proving)



Breanndán Ó Nuállain

(Ph.D. student, phase transition phenomena)

Marc Pauly

(Ph.D. student, dynamic logic hypertextbook)

Jon Ragetli

(Ph.D. student, structuring electronic information)

Maarten de Rijke

(project leader 'Computational Logic')

Yde Venema

(project leader 'Logic in Communication')

INSTITUTE FOR LOGIC,
LANGUAGE AND COMPUTATION

UNIVERSITEIT VAN AMSTERDAM