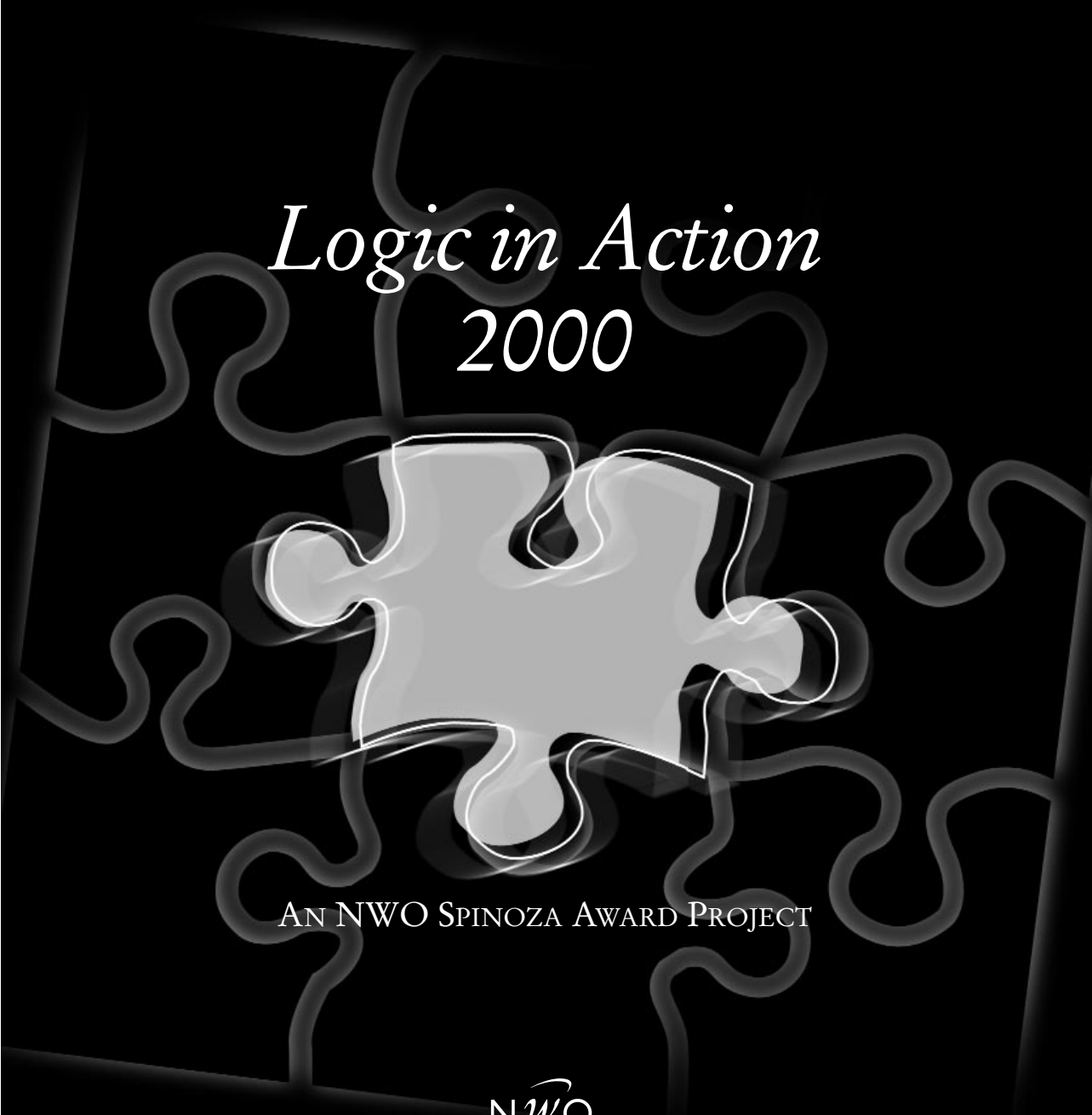
INSTITUTE FOR LOGIC,
LANGUAGE AND COMPUTATION

# *Logic in Action 2000*



AN NWO SPINOZA AWARD PROJECT

NWO

UNIVERSITEIT VAN AMSTERDAM

# *Logic in Action*

An NWO Spinoza Award Project

Leaflet and report, 2000

*Amsterdam, March 2001*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Language and Computation

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# *Logic in Action 2000*

AN NWO SPINOZA AWARD PROJECT

Dear reader,

We are proud to present the 2000 Spinoza brochure, already the fourth 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 consisted 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 2000 (section 3). Other sections include a guest column by Ruth Kempson, the embedding of Logic in Action in a larger context, and a number of short texts on logic-related topics. The preface and epilogue were written by Johan van Benthem himself.

We hope you will enjoy this overview of what went on in Logic in Action during the past year.

The editors

# Contents

# Preface LOGICAL ORDERS OF MAGNITUDE

*By Johan van Benthem*

What you see depends on where you look. As in physics, the phenomena of interest to logical research occur at different orders of magnitude. Much of what logicians have studied traditionally has 'our own measure': single statements, updates of information states, or steps in inference. These are the units that you hear, or write, or read. Accordingly, logical systems work with formulas, models, and proof calculi emphasizing these components. But there are both smaller and larger things around us. Some important events in language use or reasoning you do not see because they are too small. Immediate recognition of a statement that we hear goes so fast that we cannot manipulate this process. And this recognition is still just below the threshold of our conscious planning and manipulation: the actual 'reasoning phenomena' go down all the way to the micro-level of neurons firing in our brain. Going upward, though, other relevant cognitive phenomena are not immediately perceived by us because they are too big. Discourse involves longer-term information structures and processes, not all of them encoded in syntax or individual memory, which brings us to cognitive activities in a many-agent setting, strategies, and various forms of social organization. One major challenge for modern logic is how to draw these various orders of magnitude into its scope, with new notions and techniques, but also with the same rigor and success as the earlier core business.

On this scale, our Spinoza project has chosen the upward direction. For instance, ILLC's trademark work on 'dynamic semantics' concerns mainly single episodes of informational update in communication. But these days, one can see this research program steadily moving away from single sentences to texts used by larger groups of speakers and hearers developing their 'common ground' for broader purposes, such as decision making of various kinds. Our Spinoza work on Logic and Games points in the same direction. We are after the logic of agents' behavior in social settings, where they may have conflicting preferences over possible outcomes, and where they pursue longer-term strategies. Right now, this theme has attracted some 10 Master's and Ph.D. students in The Netherlands, and our project has initiated regular international meetings at the interface of logic and game theory, which have already hosted such major speakers as Samson Abramsky (Oxford), Rohit Parikh (New York), Ariel Rubinstein (Tel Aviv & Princeton), and Gabriel Sandu (Helsinki).

Of course, the Spinoza people themselves are also on the move with their ideas, in linguistics, philosophy, computer science, and economics. In this year 2000 alone, you could have seen them spreading the word around the globe, in Bielefeld, Bonn, Helsinki, New York, Stanford, Tel Aviv, or Torino.

Many important features of games only emerge in the long run. Optimal equilibria may only set in when the game is played very often. Accordingly, one feature of game theory that feels less familiar to logicians is its heavy use of probability and statistics. But this again demonstrates the importance of 'looking at many levels' when searching for phenomena of logical interest. When a logical system is really used, its individual steps will be repeated 'in bulk'. This often produces new emergent phenomena, that one may just have to observe, and perhaps explain later. In particular, modern automated theorem proving has hit upon surprising 'phase transitions', where small shifts in input size trigger abrupt changes from hard to simple in average computation time. One is reminded of large systems of molecules in physics generating their own emergent behavior in terms of temperature or other macroscopic properties. We need a similar theory of the bulk behavior of logic systems, under various architectures, and used in meaningful tasks requiring bulk repetition of inference steps. This is precisely the current emphasis in the 'strong arm' of the Spinoza project, being our Computational Logic laboratory. Nowadays, you will see graphs of computational experiments hanging on several office doors, with the challenge to theoreticians passing by to provide an analytical explanation.

By the way, these explanations can be as beautiful as more standard logical theory. An example from the 1970s is the 'Zero-One Law', which says that, increasing domain size for finite models, the probability of truth or falsity for any given first-order statement goes to either 0 or 1. This was certainly not

foreseen by our Frege, the designer of first-order logic - and it came just a few years after 'Lindström's Theorem' seemed to have shown all things of interest had been found concerning first-order logic. But that was just the 'end of history when just looking at one level of magnitude! In the very long run logic may drop out altogether, as with gossip, where statistical spread will blur any initial informational content. And the nice book "Dynamics of Opinion Change" by Tilburg university executive Mouwen shows how the larger-scale of opinion dynamics may be just physics after all. Nevertheless, our Spinoza project has not yet passed to a purely statistical view of what happens when we confront the adolescents or general citizens of this country. Our didactics and dissemination project is very much alive, and we hope to produce a first round of texts soon, partly inspired by our game-based research, which was predicted so well by the Dutchman Hieronymus van Alphen, in his famous poem

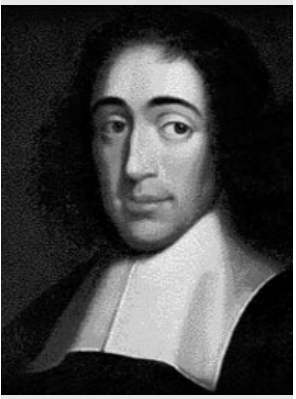
*"Mijn spelen is leren, mijn leren is spelen.*
*Waarom zou het leren mij dan vervelen?"*

Playing is learning, and learning is playing. So why would learning ever be boring?

So, our project is 'looking up' all right. But what about the other direction, i.e. all those cognitive micro-levels 'lower down'? To see the logic in those, we will have to wait for the next round of manna from NWO, when the new national stimulation project on Cognitive Sciences kicks off - just at the close of this Spinoza enterprise...

*"Mijn spelen is leren, mijn leren is spelen.*
*Waarom zou het leren mij dan vervelen?"*

# Section 1 THE SPINOZA PROGRAM OF NWO



BENEDICTUS DE SPINOZA
1632-1677

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 honor 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 20 scientists. In 2000 the prize winners were:

- Professor E.F. (Ewine) van Dishoeck, professor of Astronomy (specializing in Molecular Astrophysics) at Leiden University
- Professor D. (Daan) Frenkel, head of the department of Soft Condensed Material and director of the Computational Physics research group at the Institute for Atomic and Molecular Physics (AMOLF) in Amsterdam; also professor of Computational Macromolecular Chemistry at the University of Amsterdam and Professor of Computational Physical Chemistry at Utrecht University
- Professor D.S. (Dirkje) Postma, Professor of Pathophysiology of Respiration and in particular of Obstructive Pulmonary Disorders (Netherlands Asthma Fund), at the University of Groningen and Groningen Hospital.

# *Bridging the Divide*

**by Samson Abramsky**

***Samson Abramsky, successor to Tony Hoare as professor of theoretical computer science in Oxford, visited the Dutch Graduate School in Logic to take part in the Nunspeet Schoolweek in October 2000, where he gave a crash course on logic and games in computer science.***

**Samson Abramsky:**
**Logic in Computer Science**

Logic in Computer Science is now a large and diverse area. If one consults the Proceedings of conferences such as LiCS (the International Symposium on Logic in Computer Science) one sees a remarkable range of technical tools: finite model theory and descriptive complexity, lambda calculus, type theory, proof theory, category theory, rewriting, Kleene algebra, automata theory, topology, lattice theory, modal and temporal logic, to name just a few. Motivation ranges from semantics and design of programming languages, through program analysis and verification, to structural aspects of complexity theory. This is rich and vibrant, dynamic and fast-moving enough to be a world of its own.

By contrast, 'traditional' logic, whether mathematical or philosophical, can seem stuck in a time-warp, having, like the (briefly) restored Bourbon monarchs, 'learned nothing and forgotten nothing'. And on the other side of the divide, no doubt computer science logic may be viewed as following fashions, and not really confronting fundamental issues.

It is then refreshing for a computer scientist such as myself to find a community of 'mainstream' logicians who are open-minded and genuinely interested to explore the current developments in computer science logic, and to see the flow of information as usefully going in both directions. This is what I have found in my interactions with the Amsterdam school of logic, most recently when attending the logic school in Nunspeet to give a tutorial and an invited lecture. In particular, I have found a shared interest in a topic central to my own concerns: the 'dynamic turn' in logic, seeing logic in an extended and enriched role as an informatic calculus, a theory of the deep structure of interaction and information flow.

I also greatly appreciated the relaxed, tolerant, but intellectually keen atmosphere, and the strongly international flavor of the excellent group of students. Both a very modern community, and one drawing on excellent traditions. I look forward to continuing these interactions: we have much to say to each other.

■

# Section 2 LOGIC IN ACTION

## Mission Statement

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

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 Chapter 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.

## Narrow and Broad Conceptions of Logic

What logic is about depends on one's point of view, and current viewpoints on logic vary from very narrow to extremely wide. The topic of logic, narrowly conceived, is the study of valid inference in the formal sciences, more in particular in mathematics. The wider viewpoint on logic adopted within the Spinoza project broadens this to the relation between thought and the world, and also to the relation between thinkers that communicate about the world and about each other, as parts of that world.

Taking stock of the achievements of the past, one can say that logic in the 20th century achieved a clarification of the limits of computability. We know now that there are many interesting questions that machines – in whatever conceived way – cannot answer, so the task of logic as a foundational discipline seems to be accomplished. If one adopts a narrow viewpoint on logic, then all that remains to be done is cultivate the gardens of specialistic knowledge in the areas of model theory, recursion theory, set theory, proof theory: fields that were created by Turing, Gödel, Herbrand, Gentzen, Church, Curry, the giants of the 20th century. If one adopts a broader viewpoint, then many new tasks lie ahead, tasks that have to do with accounting for what agents (men and or machines) can do, and how they do it.

A recent trend in natural language analysis is the shift from modeling declarative language use to modeling linguistic interaction. Here the Spinoza Logic in Action tradition in dynamic epistemic logic suddenly becomes relevant. Dynamic epistemic logic provides an account of how communication between agents changes how these agents view the world and each other (changes their epistemic states). Communication is also a crucial issue in models of parallel computation: if computation is distributed over multiple processors, then an account of rational, efficient communication is needed to explain how the partial computation results are to be combined.

## 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 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 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.

## 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 challenge is to understand the balance between the richness of representations and the computational efficiency 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.

There is also a more practical strand running through the whole 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.

# *Logic, games, and satisfaction in Amsterdam*

**by Valentin Goranko**

***Valentin Goranko, a well known specialist in Modal Logic and a regular visitor to ILLC, reflects on his two month visit to ILLC in the fall of 2000.***

*"Valentin Goranko (right) and Juan Heguiabehere, bent over the map of Amsterdam"*

**Tales of Truth and Sentiments**

This was the title of a memorable event that marked my very first day in Amsterdam: Professor Anne Troelstra's valedictory lecture. Besides enjoying his historic parallels between scientists' emotions and their scientific pursuits, I found this title quite emblematic of a fact that has always fascinated me: Logic in Amsterdam is not a dry and self-enclosed scholastic exercise, but rather an epicenter of a passionate intellectual affair between mathematicians, computer scientists, linguists, philosophers, artificial intelligencers, the stage is always open for new actors. This multicultural atmosphere is not an instance of a proverbial Dutch tolerance between disciplines occupying parts of each other's life space (again, proverbially scarce here), but an essentially interactive and mutually stimulating environment, effecting the intellectual synergy which makes this place so attractive not only for tourists but for academics of various breeds.

**Logic, linguistics, games and music**

All this, and much more, in the woods of Nunspeet. I was fortunate to attend, both as a lecturer and a participant, the OzsL Autumn School Week and Accolade, organized by Jan van Eijck in the outskirts of that small town in the heart of Holland. That distinctly diverse, yet intimately focused academic event, bringing together a variety of researchers, from internationally famous scientists to beginning master and doctoral students, was a perfect manifestation of the interdisciplinary spirit of the logical enterprise in the Netherlands. Types of contexts, event calculus, tokens and occurrences, intelligent agents, unifying models for linguistic, musical and visual processing, politeness and the civilizing process, the geography of satisfiability, co-algebras and behavioral differential equations, suspicious players, almost sure validities and zero-one laws, logic in linguistics, persuasion dialogues, spatial reasoning - just some of the numerous themes discussed there, supplemented by late-night discussions on Logic, Life and Everything else. And, of course, games, games, games!

**Learning the Logic of games, playing the Game of logic**

If you ever wish to know what relates semantic evaluation, model construction and comparison and winning argumentation debates with mathematical game theory, strategies, Nash equilibria, dynamics of epistemic actions, social choice theories etc. - Amsterdam is the place to go! And, I think, "Logic and Games" is not just the current passion of Johan van Benthem, turned into fashion at ILLC, but an ultimate focus of his deeply influential multi-facetious and broadly perspective view of Logic in the context of information, cognitive, and social sciences. His inspiring lectures, papers and notes on the topic, supplemented with stimulating discussions with him and other active players on the field, sparked my desire to join the Game, too.

**Modal logic: my everlasting love**

Of course, it was a major theme of my visit, too. I learned a lot from many and long discussions with Yde Venema and had the enormous pleasure of reading and commenting on the final draft of the new state-of-the-art account of the subject,

becoming a classic before published yet - the book of Blackburn, de Rijke and Venema, the final touches of which were completed before my eyes. And, I was quite pleased that my seminar lecture on generalizing Sahlqvist formulas in polyadic modal languages (a joint work with Dimiter Vakarelov) was met with unexpectedly live interest for such a technical topic - which in the Kingdom of modal logic is more than a compliment.

**Can't get no satisfaction**

Many more exciting events happened around me during these two months, and one of them was the very interesting workshop "Satisfaction in the Netherlands", organized by Maarten de Rijke. Added to that was the satisfaction from attending lectures of distinguished visitors such as Edsgar Dijkstra, Neil Jones and Samson Abramsky, and from the number of enjoyable and stimulating discussions I had with people at ILLC.

Even the long and lonely evenings of quiet work in office were satisfying, especially when the weather was co-operating, and it was, much too often. Yet, it gave me many chances for exploration of the non-academic faces of this amazing, bustling, crazy, rainy, lively, gezellig, unforgettable city of Amsterdam in which everyone falls in love from first sight. On a personal note, well, not everything was perfect. Besides the impossible dream of a dry and sunny day once a week, I wish the bikes here had hand brakes, too. Still, I had all reasons for satisfaction apart from one: one can never have enough if it.

*Bedankt ILLC,*
*en toet siens!*

■

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 sub projects, 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.

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 2000 shows, the project is the natural habitat for logicians who initiate activities.

# Section 3 LOGICIANS IN ACTION 2000

*In this section we report on the main research activities of the three subgroups in the year 2000, and list the most important activities and events that have been organized.*


"MASTER MIND, A PUZZLING GAME FOR LOGICIANS."

## 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 ultimate objective of a calculus of information science, the renowned Amsterdam traditions in dynamic semantics (interpretation), and modal logic (information), and the reviving field of game theory (action) here find a point of convergence.

Amsterdam is an international center for modal and related logics, and this type of logic provides 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 internationally successful paradigm of dynamic semantics, well established in Amsterdam, feeds the logical one with conceptual and computational issues which arise in the study of natural language interpretation and reasoning. Game theory and epistemic 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 2000, we have continued to extend the reach of this paradigm, thus further increasing our grip on information flow from all perspectives.

In the area of modal logic proper, Maarten Marx and Yde Venema wrote a state of the art survey on decidability and complexity issues in modal logic. Yde Venema carried out foundational research on applications of game theory to axiomatization problems in modal logic; together with Ian Hodkinson and Szabolcs Mikulàs he found a general method to obtain an axiomatization of the class of complex algebras of an arbitrary variety of algebras; in particular, this solves a problem concerning the axiomatization of so-called group relation algebras. Venema also proved that any modal logic in a language with polyadic

operators can be simulated by an ordinary modal logic with diamonds; this simulation operator transfers most natural properties of modal logics. Alexandru Baltag deepened our understanding of the connections between modal logic and co-algebras; by working with natural transformations between categories of co-algebras he drew an interesting landscape of co-algebraic modal logics. He also showed that the neighborhood semantics of non-normal modal logics finds a natural place within the co-algebraic framework.

One of the main theoretical themes relates to the startling issue of modeling ''Who knows what?" in dynamic 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 such 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.

Alexandru Baltag continued his investigations on such dynamic epistemic processes, extending it to incorporate game theoretic issues. For instance, by adding nondeterminism to his epistemic action logic, he managed to express several interesting game theoretic phenomena in his language, such as Nash equilibria in perfect information games, and rationalizability. Also, he can now use his calculus of epistemic processes, which he extended with features like parallelism and communication, for game-theoretic applications, such as the derivation of the outcome of a game from a given strategy profile. Annette Bleeker extended her analysis, in this framework, of encrypted message passing, and reported on 'Epistemic action and Change' at LOFT-4 (Logic and the Foundations of Game and Decision Theory).

This conference in Torino had a quite substantial Spinoza coverage: apart from Baltag's and Bleeker's talks, there were presentations by Van Benthem, Van Ditmarsch and Pauly. The thesis defense of Hans van Ditmarsch in the Fall of 2000 got nationwide press coverage. Van Ditmarsch gives an in-depth demonstration of the power of the Spinoza tradition in epistemic dynamic logic, in an analysis of the mystery game *Cluedo*. In a somewhat different direction, Marc Pauly applied epistemic dynamic logic to the investigation of coalition power in election situations. The novel feature of Pauly's approach involves a dynamic perspective on the so-called *effectivity* functions, which model the powers of certain groups of voters to force election outcomes.

In the case of voting, one can model multi-stage voting procedures with intermediate outcomes: not quite enough for a full analysis of the Bush-Gore election comedy of November 2000, but coming close...

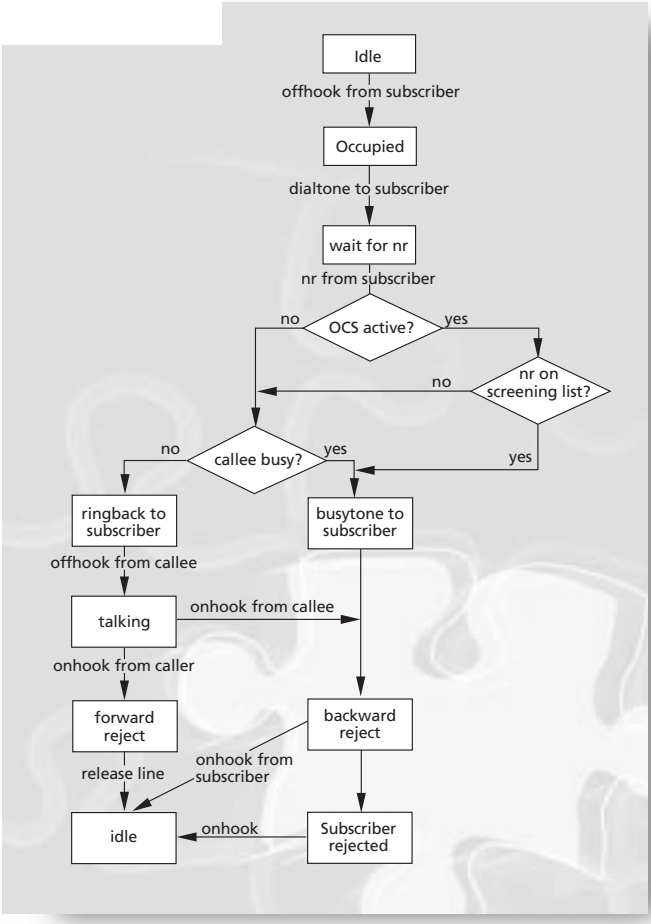
Related to this work is a result by Yde Venema which states that Van Benthem's conjectured axiomatization of game algebras is indeed complete. Different from Goranko's earlier proof, Venema shows that every abstract game algebra can be represented as a concrete collection of effectivity functions.

In the area of the theory of interpretation, Dekker, in joint collaboration with van Rooy studied further issues on the semantics/pragmatics interface, and presented analyses in pragmatic, and game- and optimality theoretic terms. Firstly, a coherent formal model of the meaning of, update with and support for first order information has eventually been completed. The model integrates and extends the major insights and tools of discourse representation theory and dynamic semantics with key concepts from the philosophical pragmatic tradition. Among other things, the system deals with the resolution of incomplete expressions. We have also given a formal characterization of the circumstances under which information exchange is sound, in the sense that received information, even if transmitted by means of open expressions, is grounded in the speaker's support for the utterances made. Conceiving of the linguistic (semantic/pragmatic) process of information exchange as the execution of a program, this determines the conditions under which the program is (provably) correct.

Secondly, we have furthered the study of the parallels between Dynamic Semantics and Game Theoretical Semantics. The outlook upon information exchange in dialogue as a game between interrogating and informing agents, enhances our understanding of some, at the face of it puzzling, facts about the effects of negations, questions, and conditional sentences upon anaphoric structure. Not only does this outlook motivate a kind of information structure which naturally blocks the presence of referential uses of terms figuring in these constructions, it also suggests a natural explanation of the cases in which this type of blocking is absent. Thus, simple systems of dynamic interpretation are naturally extended with functional terms (functional indefinites and functional pronouns), thus yielding an account of the notorious problem of quantificational (and other) subordination.

## 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 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.

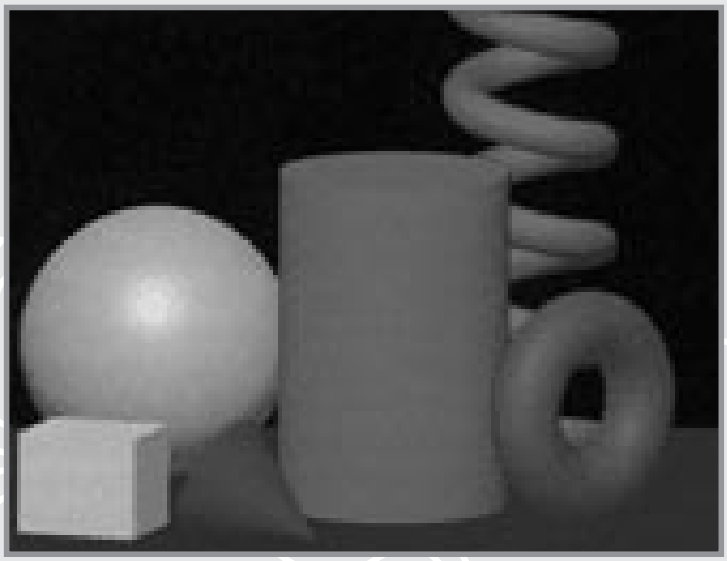



"STATE MACHINE FOR THE NETWORK SIDE OF THE PUBLIC SWITCHED TELEPHONE NETWORK WITH THE FEATURE 'ORIGINATING CALL SCREENING' ADDED." (ORGINATING CALL SCREENING FORBIDS CALLS TO NUMBERS ON A SCREENING LIST.)

# *First International Congress on Tools for Teaching*

**by Jan van Eijck**

***In June 2000, the First International Congress on Tools for Teaching Logic took place in Salamanca, Spain. This congress, organized by professor Maria Manzano from the University of Salamanca, brought logicians from Europe, the US and South America together to compare tools and methods of state-of-the-art logic teaching.***



Maria Manzano is the coordinator of Aracne, a network of South American academic centers that was set up for exchanges in the area of academic education, and strengthening this network was one of the aims of the conference.

Dutch dissemination of logic was quite strongly represented at the conference, with Dick de Jongh, Jan Jaspars, Raffa Bernardi, Richard Moot, Jan van Eijck and Josje Lodder as speakers. Dick gave a in-depth analysis of advantages and disadvantages of various approaches to logic that can be taken in a first course: tableaux, sequents, natural deduction, Hilbert calculi, resolution and CNF/DNF rewriting. (His current favorite is resolution.) Jan Jaspars presented his growing arsenal of tools for illustrating key concepts of logic, to general acclaim of the audience. Raffa gave an eloquent account of her experience with teaching categorial grammar to Italian secondary school students, using the Grail system developed at Utrecht University. Grail itself was presented at the conference by Richard Moot. Jan van Eijck reported on the new ILLC course 'reasoning and computation' ('structuren van de informatica') where first steps in logic and reasoning are combined with and applied to functional programming. Josje Lodder gave an overview of the logic teaching activities of the Dutch Open University.

John Etchemendy, master logic toolsmith from Stanford, was present to tell us the latest news about Turing's World, Tarski's World, Hyperproof, and their ilk. The latest news is that the Stanford logic toolbuilding industry is still losing money, according to John because too many students use illegal copies of the software, and that Stanford has decided to stop funding the toolbuilding enterprise.

Many of the other contributions focussed on various tools for logic teaching, most of them based on tableaux. The Aracne connection brought in a large South American attendance, with contributions from Brazil, Mexico, Venezuela, Argentina, and Uruguay. In the course of the conference we learned about the great enthusiasm for logic teaching in a part of the world that we still have relatively little contact with. It also became quite clear that the main language of Latin academia is Spanish, and some of the speakers felt rather ill at ease with English. During after-conference hours, when the international audience was finding its way in the restaurants and bars of Salamanca, the roles were reversed.

# Logic

Salamanca is a university town of long standing, several centuries older, in fact, than even its oldest Dutch counterpart, and the surroundings of the conference were truly stunning. The conference dinner, for instance, took place in the historic former palace of the Archbishop of Fonseca. It opened with classical guitar music, and was concluded by community singing with flamenco accompaniment. When the flamenco guitarist took his leave, Dick de Jongh was suddenly addressed in Spanish by the maestro as un hombre muy sympatico, whose appreciating attitude during the concert – Dick had been in the first row – asked for this spontaneous acknowledgement. When the two men were shaking hands it struck at least some members of the audience that Dick himself would not look the least out of place as a member of a flamenco orchestra.

In the enthusiasm of the moment, Dick de Jongh and Jan van Eijck volunteered to organize a follow up conference in Amsterdam, perhaps in a few years time. As became clear during the conference, rapid and exciting changes are taking place in the area of logic teaching, and it seems worth while to monitor this development. But it is surely going to be hard to beat our Salamanca hosts for hospitality.
■

In 2000, these matters were pursued along a number of concrete lines, organized in two streams: Computing with Logic, and Computing with Language and Information. 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. Carlos Areces completed his PhD dissertation, which is partly based on joint work with Blackburn and Marx, and which includes an extensive analysis of the expressive power of so-called description logics in terms of hybrid logics; together with De Rijke, he analyzed reasoning with various kinds of knowledge bases in a variety of such logics.

The year 2000 witnessed a further increase in the group's emphasis on experimental evaluations of reasoning methods. Supervised by Van Benthem and De Rijke, Ó Nualláin studied statistical phenomena in the area of propositional satisfiability checking. In particular, his work deepened our understanding of so-called restart strategies and made a number of interesting discoveries concerning runtime distributions of Davis-Putnam algorithms. Areces, Gennari, Heguiabehere and De Rijke developed, implemented, and evaluated new translation-based reasoning methods for modal logic, based on syntactic encodings of the tree model property. Together with Ohlbach, Nonnengart and Gabbay, De Rijke wrote a state-of-the-art survey of translation-based reasoning methods for modal logic for the *Handbook of Automated Reasoning*.

One of the main motivations for the continued investigation of translation-based reasoning methods is the fact that many reasoning tasks for modal and modal-like logics are NP-, PSPACE-, or even EXPTIME-hard, and, hence, that there is usually no single algorithm which can be developed, implemented and then used as a black box that performs well on all inputs. Instead, a *variety* of qualitatively different algorithms and heuristics for solving reasoning tasks is needed, each of which performs well on only a limited class of inputs. *Combined*, such solvers should cover as many inputs as possible. A similar motivation underlies work by Gennari on constraint satisfaction problems, which focused on the definition of a theoretical framework, based on iterations of functions, that can express most well-known propagation algorithms. The same motivation also formed the starting point for work by De Rijke and Stol on adaptive algorithms for model generation for modal logics.

Combined logics were the focus of a survey by De Rijke, written together with Bennet, Dixon, Fisher, Franconi, Horrocks, and Hustadt. And combinations of model checkers were investigated by Franceschet, Montanari, and De Rijke, who showed that combined model checkers tend to behave much better than combined theorem provers: even in the presence of very strong forms of interaction, the communication overhead is usually small and often non-significant.

Van Eijck and Heguiabehere continued their work on *Dynamo*, a language that implements a process interpretation of dynamic predicate logic, teaming up with Ó Nualláin to provide this work with a foundation, in the form of a tableau calculus for dynamic predicate logic.

The group's activities in the Computing with Language and Information stream range from fundamental to experimental to applied. On the foundational side, De Rijke, together with Alechina and Demri, studied algorithms for checking constraints on so-called semistructured data. Amongst others, improved (and essentially optimal) upperbounds were obtained for path inclusion constraints.

The NWO-funded project 'Derive!' entered its second year during 2000. This project is aimed at bringing recent advances in natural language processing and computational logic to bear on information extraction and retrieval. 'Derive!' addresses the problem of finding content in natural language documents. Monz spent a large part of 2000 testing and refining a general purpose information retrieval engine called RETRIEVE 0.96

Experiences from these implementation efforts fed into joint work with Aiello and others on document analysis, where combinations of 'light-weight' logical and linguistic techniques were used to dramatically improve the quality of a system for analyzing the structure of documents. Monz also worked on the use of light-weight logical tools in the setting of document fusion.

Areces, together with Bernardi, worked on modal analyses of natural logic systems and multi-modal categorial logics, with a special focus on proof-theoretical and polarity-related aspects.

Ongoing work by Monz, De Rijke and a number of undergraduate students is aimed at developing and evaluating psychologically motivated document classification algorithms, and at discovering interesting semantic relations both inside and between documents.

More practically oriented, the study of the use of glossary-based navigation tools for exploring and organizing the contents of electronic handbooks led to a prototype implementation of a glossary based browser for the *Handbook of Logic and Language* developed by De Rijke. This work is part of the Logic and Language Links project funded by Elsevier Science that reached its first year's milestones with the Master of Logic thesis of Ragetli. Further work here – carried out by Chidlovskii, Ragetli, and De Rijke, was aimed at automatically constructing so-called wrappers for linking the electronic handbook to external information sources such as bibliography servers and search engines. Using Monz' retrieval engine, Ragetli and De Rijke experimented with various methods for linking the glossary-based structure to the *Handbook*.

During 2000, the Computational Logic group received a number of major grants. First, a proposal entitled 'Simulating and Testing for Feature Interaction' was awarded by NWO; this project is aimed at developing new methods for detecting feature interaction in telecommunication systems, based (in part) on satisfiability testing. Second, De Rijke received a grant to complete – together with Areces – a survey on computational methods for modal logics.

The group organized the computational logic seminar, which featured prominent speakers such as Neil Jones and Yuri Gurevich. The group also organized an afternoon on satisfiability research in The Netherlands. Internationally, the group was involved with major initiatives on the interface of logic, language and information, including ESSLLI, FoLLI, IFCoLog, AiML, ICoS, and HyLo.

Plans for 2001 include a substantial number of research proposals as well as a merger of the Computational Logic group with the Applied Logic Lab, to reflect existing research collaborations within ILLC.

## Dissemination of Logic

GREGOR REISCH, 'MARGARITA PHILOSOPHICA', STRASSBOURG 1504. "A BATTLE OF METHODS: CALCULATING WITH THE ABACUS OR WITH ARABIC NUMERALS ON PAPER."

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 flourishing 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.

Combining theory of programming language semantics with development of practical skills has been one of the challenges of a new course in computational semantics set up by Venema and Van Eijck, with guest lectures by Krzysztof Apt. The lectures covered the theory of the main programming paradigms (imperative programming, logic programming and functional programming) while the laboratory sessions focussed on implementation of key concepts from these paradigms (dynamic versus static variable binding in procedure calls in imperative programming, unification in logic programming, beta conversion in functional programming). Heavy use is made of the prototype implementations in Haskell of 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) that were developed in 1999 for purposes of course rejuvenation. The course will be repeated with improvements in 2001.

A further challenge is to present programming language semantics and natural language semantics from a common perspective. Van Eijck attempted this in a series of lectures on *Compositional Semantics and Type Theory* for Ph.D. students in linguistics at Uil-OTS, Utrecht, in the Fall of 2000. See *http://www.cwi.nl/~jve/ots2000/*. Point of departure was the truism that interpretation of texts both uses context and sets up new contexts. The lectures demonstrated how this context processing can be modeled with a flexible system of type scheme patterns and type scheme pattern matching. The principles involved were illustrated by means of implementations of toy fragments, with mechanisms for pronoun reference resolution in context.

Further didactic innovations were made in a course on *Reasoning and Computation* (Van Eijck and Doets), where computer science students get acquainted with formal concepts in mathematics in the context of concrete prototype implementations of those concepts in Haskell. See *http://www.cwi.nl/~jve/RAC*. Leen Torenvliet experimented with an on-line Introduction to Prolog.

Work on *Dynamo,* a language that implements an executable process interpretation of dynamic predicate logic, was pursued by Van Eijck together with Heguiabehere and Ó Nualláin. They reported on an application of tableau reasoning with dynamic first order logic to natural language processing at the second ICOS (Inference in Computational Semantics) conference in Dagstuhl, on connections with logic programming at WFLP'2000 (International Workshop on Functional and Logic Programming) in Benicassim, and on foundational issues at the Edinburgh Festival Workshop on Foundation and Inference. A journal paper on Tableau Reasoning and Programming with Dynamic First Order Logic was accepted for publication. Right now, the Dynamo team is working on strengthening the connections with free variable tableau theorem proving. Further information can be found at *http://www.cwi.nl/~jve/dynamo*

In 2000, a draft of a booklet on 'Computing, Reasoning and Calculation', with internet software, was prepared by a Spinoza team consisting of Van Eijck, Jaspars, Ketting and Pauly. This is the first booklet in a new series *Information in Context*, to be issued by Amsterdam University Press for use in secondary schools. A support team of secondary school teachers is providing feedback. In the Spring of 2001 the draft will be used for trial runs. The *Information in Context* series is modeled after a successful *Text in Context* series in literary studies, also published by Amsterdam University Press.

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. This material is now being adapted for use in the Information in Context series.

A joint initiative with the Logic in Communication group – the reading group on Game Theory – had a successful second year, with several workshops where work from a wide variety of disciplines (mathematics, linguistics, economics, philosophy, social sciences) was presented and discussed.

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 completed the work plan for the first year. In Spring 2001, the work will be continued by Caterina Caracciolo.

A final important event in dissemination is the publication in Spring 2001 of the long-awaited *Modal Logic* textbook by Patrick Blackburn, Maarten de Rijke and Yde Venema. The book is part of the Cambridge Tracts in *Theoretical Computer Science* series (Cambridge University Press).

# Section 4 GUEST COLUMN

## Dynamic Syntax

*By Ruth Kempson*

*Professor Ruth Kempson from King's College, London, gave the Spinoza-Logic-in-Action invited talk at ESSLLI, the regular European summer conference on Logic, Language and Information, that had its Summer 2000 meeting in Birmingham, UK.*

Knowing a language means knowing how to segment sounds into words, and then work out from those words what a speaker has intended to convey. This view of language may seem such commonsense as to be banal. However it is almost universally rejected. The standard view is that a language is a set of principles that induce structure defined over the words of a sentence, with semantic rules which determine how sentence meanings are built up on the basis of the meanings of words and their structural arrangement - knowledge of language is knowledge of this set of principles, and models of language use should take such models as their point of departure.

Seen this way, natural languages present a number of puzzles. The first is the discontinuity effect in which a word or word sequence may be in the wrong place for combining straightforwardly with its immediate neighbors. For example, in Mary John says should never have gone out, the first word Mary is in some sense misplaced, since it has to be interpreted as subject of have gone out, not with John. According to Chomsky, such structures demonstrate the 'imperfection' of natural languages. The second problem is the intrinsic meaning of a word may be systematically weaker than the interpretation which it has in context. Pronouns are a case in point. He saw her means that some identified person saw someone at some previous point in time but who saw who and when is provided by the surrounding context. These problems have received a lot of recent attention, but one assumption has gone entirely unchallenged – that language structure should be characterized independently of the intrinsic left-right dynamics of language processing. In consequence, there has been tension between the explanations of how words are put together to form sentences, without any reference to context, and explanations of how the meaning of such sentences is built up, with input from context.

The Dynamic Syntax framework developed by Wilfried Meyer-Viol, Dov Gabbay and myself is a model of information growth for language which solves these problems together. In it, each logical form which corresponds to one possible interpretation of a sentence is represented as a tree structure; and the process of building interpretations is a monotonic process of building partial trees following the sequence of words from left to right leading to such completed trees as output. When Dov and I started work together, our aim was to model how a hearer builds up a structure representing interpretation without commitment to the structural properties of language. However we found with Wilfried that in defining partial structures representing content and how they are built up, we had stumbled on a putative grammar formalism; for we were able to articulate natural solutions to an array of syntactic puzzles that led to natural typologies for cross-linguistic variation. On this view, the two problems of discontinuity and pronoun construal are defined as forms of structural underspecification that get resolved during the construction process and can be seen as different aspects of the same phenomenon, that the interpretation process for language involves structural growth leading to logical forms representing interpretation. The Spinoza lecture at ESSLLI 2000 presented a case study in support of this view, urging that the time had come to shift to a grammar formalism in which the dynamics of structural underspecification and its resolution in language processing is central.

Dynamic Syntax is a natural extension of ideas about concepts of logic and interpretation developed during the 80's and 90's. Firstly, it follows a period in which pragmatists and semanticists paid increasing attention to the partial nature of information available in the interpretation process. Secondly, the tools for developing formal accounts of the dynamics of information growth are only now getting better understood, in particular as the rapid expansion of the development of programs for computers fuels research on formal specification of procedures. It is against the computer science background that Dov defined the Gabbay Labelled Deductive Systems methodology, and it was during the period of its development that he and I started work on a model of language which, when Wilfried brought us the delights of the epsilon calculus and the logic of finite trees , was transformed into the present model.

The view that knowing a language is knowing how to use it in parsing fits well with the general spirit of the Spinoza project, echoing the van Benthem view that we should extend our focus beyond static concepts of information description to include the modeling of how information gets to be established. As an encouraging teacher will say, it is not just the result that counts, it is the process of getting there.

# Section 5 LOGIC IN ACTION AND ITS CONTEXT

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

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 Science
- Applied Logic Lab, Faculty of Social and Behavioural 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*

INSTITUTE FOR LOGIC,
LANGUAGE AND COMPUTATION

## Logic Actions in The Netherlands

The national habitat of the Spinoza project Logic in Action 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 all over the country.


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 Utrecht (1999) and Edinburgh (2000). Students can apply for a grant to participate, *Logic in Action* sponsors the annual Spinoza Lecture (see page 29), and, moreover, project leaders are involved in lecturing and organization. *Logic in Action* also provides all OZSL PhD 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.

# *Logic in Action from the students' pespective*

***In this section the Spinoza PhD students were asked for their association with the words 'Logic in Action'. Below are there answers.***

**Carlos Areces:**
I'm a computer scientist turned logician, but old habits die slowly, and I still keep (and plan to keep keeping) trying "to put things to

work." This is just the way I think about the field: theory should be backed up with practice, and theorems with empiric testing. I believe this is the spirit of the whole Computational Logic Group: we do Logic, but not only in paper and not only by itself. Logic in Action, what else?

**Christof Monz:**
First of all, I'm not a logician and frankly speaking, I'm not really interested in logic as 'l'art pour l'art'.

But it is amazing to see what a powerful tool logic is, when integrated into applications; or to use the theme of the project, when 'logic is in action'. Applications in Computational Linguistics, Information Science, and Artificial Intelligence, to mention some, already use logic as an essential component, and it is one of the aims of the computational logic group within the ILLC to investigate how logic can be further and better exploited for real-world applications.

**Juan Heguiabehere:**
For me, 'Logic in Action' evokes an ideal state, in which theories are developed and put to use. For I think that a formal system, while meriting study on its own right, only comes to fruition when it describes a phenomenon and can be used to explore its potential. Finding the connection between a theory and a

phenomenon is exhilarating, but only the beginning: one can then put it o use, harnessing the results of the theory to make powerful tools. Sometimes, the very use of those tools makes patterns show up which lead to yet more insight on the matter; the challenge never grows old, and the rewards are plentiful.

**Annette Bleeker:**
Where logic generally attempts to formalize a process of reasoning (e.g. like that of the human brain), action seems to be more connected with the conclusions of such reasoning – at least, that is often desirable. In a very literal sense, one can also look at what is the "logic" in occurring actions, by reasoning about one's own or other one's actions. That is

the way I interpret the name of the "Logic in Action" project in relation to my own research. I am exactly interested in the changes (e.g. of agents' knowledge) that actions invoke, and in what way logic can show those changes as being encoded in the actions. Literally encoded, like the encoding of an encrypted message, or implicitly encoded, as in a move in a game, which allows players to keep things public or secret. I think it is a challenge to find the logics behind such mechanisms, or even more: to bring some logics into actions that need it!

**Marco Aiello:**
There are two readings for the phrase 'Logic in Action' and to both I can

relate my research in spatial representation and reasoning. On the one hand, I am interested in putting logic to work. I use (modal) logics of space to model and analyze images, may they be pictorial scenes, scanned document images or medical images. On the other hand, I am interested in modeling space, and action is almost always tied by necessity to space. Our

everyday actions need space to be performed. Either way you look at 'Logic in Action' there is plenty of space and, let me add, need for research in spatial representation and reasoning.

**Marc Pauly:**
Playing a game is logic in action: If I play the queen of hearts, what can my opponent do as a response, what should she do? What cards does she believe me to hold in my hand, and

how could I take advantage of this belief? Analysis of games requires a logic OF action which can describe interactions between players. Traditional logics of action have focused on a single agent, putting everything else into the environment. Current developments focus on action in games and incorporate the different players explicitly into the model. There's action in the logic of action...
■

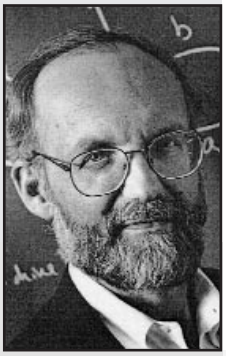
## Logic Actions Worldwide

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:

# Epilogue IN MEMORIAM JON BARWISE

*By Johan van Benthem*

A project like ours seems in perpetual upward mode, just as any scientific discipline. Individual researchers may know their failures and disappointments – but every year always has a happy resultant vector of continued progress for the larger community. But some years also bring losses that are painful and irreplaceable, and whose hurt cannot be relieved by wrapping it in upbeat prose. In the year 2000, our international community lost a person who was a mainstay of the field. The following is an excerpt from an obituary published by his American colleagues.



K. JON BARWISE

K. Jon Barwise, a world-renowned logician, died of cancer on March 4, 2000, in Bloomington, Indiana, at the age of 57. He was College Professor of Philosophy, Computer Science, and Mathematics at Indiana University since 1990. Before that, he was a professor of philosophy at Stanford, as well as the first director of the Center for the Study of Language and Information, and of the Symbolic Systems Program. Throughout his prolific career, Barwise sought to develop a better understanding of information content: how it is expressed in language, computers, or graphical representations, and how it is transferred from one form of representation to another. His first book *Admissible Sets and Structures* (1975) is a mathematical study of the expressive power of formal languages. *Situations and Attitudes* (1983), coauthored with John Perry, introduced 'situation semantics' as a new philosophical and mathematical approach to the study of meaning in natural languages. Barwise's third book, *The Liar: An Essay on Truth and Circularity* (1987), coauthored with John Etchemendy, studied self-referential claims using new developments in 'non-well-founded set theory'. With Larry Moss, he continued these studies, applied to a wide variety of phenomena in computer science, linguistics, and logic, which was presented in *Vicious Circles: On the Mathematics of Circular Phenomena* (1996). In his fifth research monograph, Information Flow: *The Logic of Distributed Systems* (1997), coauthored with Jerry Seligman, Barwise proposed a theory of how information flows through complex systems as diverse as computers and natural languages. Central to this theory is the notion of an information channel, preserving information transmitted through a complex, causally interacting system. The key notions of a new information theory pioneered in these works are still being applied and extended today.

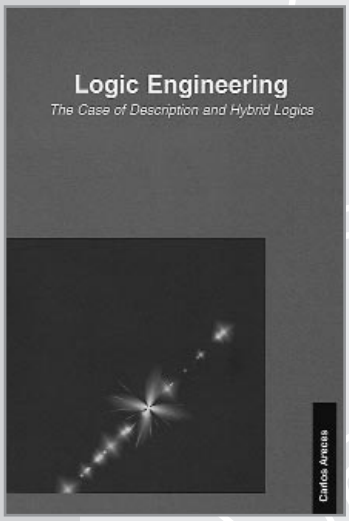
In addition, Barwise authored or co-authored nearly 100 articles on a broad range of topics, and (co-)edited several landmark volumes, including *The Handbook of Mathematical Logic* (1975), *Model-theoretic Logics* (1985), and *Logical Reasoning with Diagrams* (1996). He was also deeply committed to teaching, including the development of innovative courseware. With Etchemendy, he published a series of influential textbooks, including *The Language of First-order Logic* (1990), *Tarski's World* (1991), *Turing's World* (1993), *Hyperproof* (1994), and *Language, Proof and Logic* (2000). In the larger academic world, Barwise was instrumental in many organizational initiatives, most recently the creation of the new 'School of Informatics' at Indiana University, which spans the humanities and sciences. During the last year of his life, Barwise conducted an extensive email correspondence with family, friends, and colleagues, cataloging his courageous efforts to deal with and surmount his illness, and his philosophical reflections on life, death, and logic.

Jon was one of those people who define a whole field. Students and colleagues in other continents who had never even met him felt their work shaped by the force of his ideas and personality – through the great power of his publications. The community as a whole will surely miss him as one of the key thinkers and leaders pursuing a broad vision of logic as a fundamental analysis of information and cognition. But to me personally, there is the sudden loss of an inspiring collaborator, a steady support for our Dutch professional community, and a personal friend, who found time for attending to the needs of others, even as his own was running out. My own world is suddenly lonelier since March 4 of the year 2000.

# *Logic Engineering*

**Carlos Areces**

***For many years "Logic" was "Classical Logic," mainly classical first-order logic, and there were good reasons for this. To mention some, first-order logic offers high expressive power, simplicity, good behavior (both syntactically and semantically), and a clean and well developed model theory.***




This is just a complicated way of saying that first-order logic is beautiful...for many tasks. But when we think about applications requiring effective inference, first-order logic is simply not the choice: its satisfiability problem – i.e., the problem of determining whether there exists a model in which a given first-order formula is true – is not decidable. In addition, first-order logic sometimes does not measure up to the task at hand. It cannot, for example, capture the fact that one relation is the transitive closure of another one, and this might be crucial for a certain modeling task.

For these reasons mainly, first-order logic has been loosing its privileged position as a representation formalism in many areas where applications requiring effective inference methods are central, such as Artificial Intelligence, Knowledge Representation, Computational Linguistics, Software Design and Verification, or Databases. In these fields, the applications themselves have given rise to new formalisms, specially tailored for the problems to be addressed. In some cases, like in the early days of Artificial Intelligence, this growth has even been chaotic, with hundreds of new proposals, and very restricted means to evaluate them.

As an answer to this problem, a new field of Logic Engineering is starting to develop. To judge the appropriateness of the name, consider the following definition of *engineer*

**engineer:** n. one who designs or makes, or puts to practical use [...]

In line with its name, Logic Engineering studies ways to construct new formalisms, with good properties like decidability, appropriate expressive power, effective reasoning methods, and good meta-logical characteristics (completeness, interpolation, etc.), for a given, particular need.

How do we design "made-to-fit" logics? That is the topic of my PhD thesis which I completed last October. And after some months of celebrations and traveling (visiting my family and friends in Argentina for Christmas is always a good excuse to escape for some weeks the cold European winter), I have returned to Amsterdam to join again the staff of the Institute for Logic, Language and Information as a post-doc.

I am now a member of the NWO funded project STeFI (Simulation and Testing for Feature Interaction), which aims to put the theoretical work developed in the thesis to direct, practical use.

(Very) Informally, features are modules of functionality that modify the behavior of a basic system. Let me give you an example: the basic service provided by your cellular phone might not let you divert your call to another number when you are away; but you can add this new commodity by calling your network provider. The most challenging theoretical question is to provide a logical formalism which can account for this modification in the behavior of the system in a flexible way, and devise algorithms to automatically verify its properties.

And the telecommunication domain is exactly the main application field that STeFI will address. The group is in close collaboration with KPN Research, which plays the fundamental role of keeping our feet on Earth and not letting us get lost in a maze of theorems, lemmas and corollaries.

■

# Appendix 1. GUESTS AND EVENTS

## Events

- Games in Logic, Language and Computation, Amsterdam, *14 April 2000*

- Ninth Annual CSLI Workshop on Logic, Language & Computation, Stanford, *26 - 28 May 2000*

- Games in Logic, Language and Computation 2, Amsterdam, *23 June 2000*

- Co-Algebra Meeting, Amsterdam, *18 July 2000*

- Inference in Computational Semantics (ICoS-2), Schloss Dagstuhl, *29-30 July 2000*

- ESSLLI'00, 12th European Summer School in Logic, Language and Information, Edinburgh, *6-18 August 2000*

– Financial support: Spinoza lecture by Ruth Kempson (see also page 29); Vienna Circle lecture by Theo Kuipers; sponsoring of two students from National Chung Cheng University in Vietnam
– Courses/Lectures by: Carlos Areces, Johan van Benthem, Christof Monz, Marc Pauly, Yde Venema

- Tbilisi Summer School in Language, Logic, and Computation, Tbilisi, Georgia, *29 August - 8 September 2000*

- Advances in Modal Logic 2000, University of Leipzig, *4 - 7 October 2000*

- Promotion Carlos Areces. "Logic Engineering. The Case of Description and Hybrid Logics", Amsterdam, *12 October 2000*

- OzsL School week, Nunspeet, *23 - 27 October 2000*

- Games in Logic, Language and Computation 3, Nunspeet, *26 October 2000*

- An afternoon on Satisfiability in the Netherlands, Amsterdam, *3 November 2000*

- Games in Logic, Language and Computation 4, Groningen, *21 November 2000*

- Sinn und Bedeutung V, Amsterdam, *18 - 20 December 2000*

- Computation Logic Seminar, *weekly*
- Seminar on Games and Logic, *bi-weekly*
- Dynamo Workshop, *weekly*

## Guests

- Rohit Parikh
  *New York University*
- Ramon Jansana
  *University of Barcelona*
- Guram Bezhanishvili
  *Tbilisi State University*
- Mai Gehrke
  *New Mexico State University, Las Cruces*
- Rob Goldblatt
  *Victoria University, Wellington*
- Valentin Goranko
  *Rand Afrikaans University, Johannesburg*
- Samson Abramsky
  *Oxford University*
- Neil Jones
  *University of Copenhagen*
- Joachim Niehren
  *University of Saarland*
- Hans Kamp
  *University of Stuttgart*
- Yuri Gurevich
  *Microsoft Research*
- Natasha Alechina
  *University of Nottingham*
- Patrick Blackburn
  *University of the Saarland/ LORIA*
- Enrico Franconi
  *University of Manchester*
- Massimo Franceschet
  *University of Udine*
- Henry Chinaski
  *CWW*

# Appendix 2. PHOTO GALLERY

MARCO AIELLO
(PH.D. STUDENT, SPATIAL REASONING, VISION, IMAGE PROCESSING AND INTERNET TECHNOLOGY)

CARLOS ARECES
(POST-DOC, THEORY AND APPLICATIONS OF RESTRICTED DESCRIPTION LANGUAGES)

ALEXANDRU BALTAG
(POST-DOC, 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)

BOUDEWIJN DE BRUIN
(PH.D. STUDENT, LOGIC, GAME THEORY AND PHILOSOPHY)

PAUL DEKKER
(PROJECT LEADER 'LOGIC IN COMMUNICATION')

JAN VAN EIJCK
(PROJECT LEADER 'DISSEMINATION OF LOGIC')

ROSELLA GENNARI
(PH.D. STUDENT, CONSTRAINTS AND COMPUTING WITH MODAL LOGIC)

JUAN HEGUIABEHERE
(PH.D. STUDENT, COMPUTING WITH DYNAMIC SEMANTICS)

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)

BREANNDÁN Ó NUÁLLAIN

(PH.D. STUDENT, PHASE TRANSITION PHENOMENA)

MARC PAULY

(PH.D. STUDENT, DYNAMIC LOGIC HYPERTEXTBOOK)

JON RAGETLI

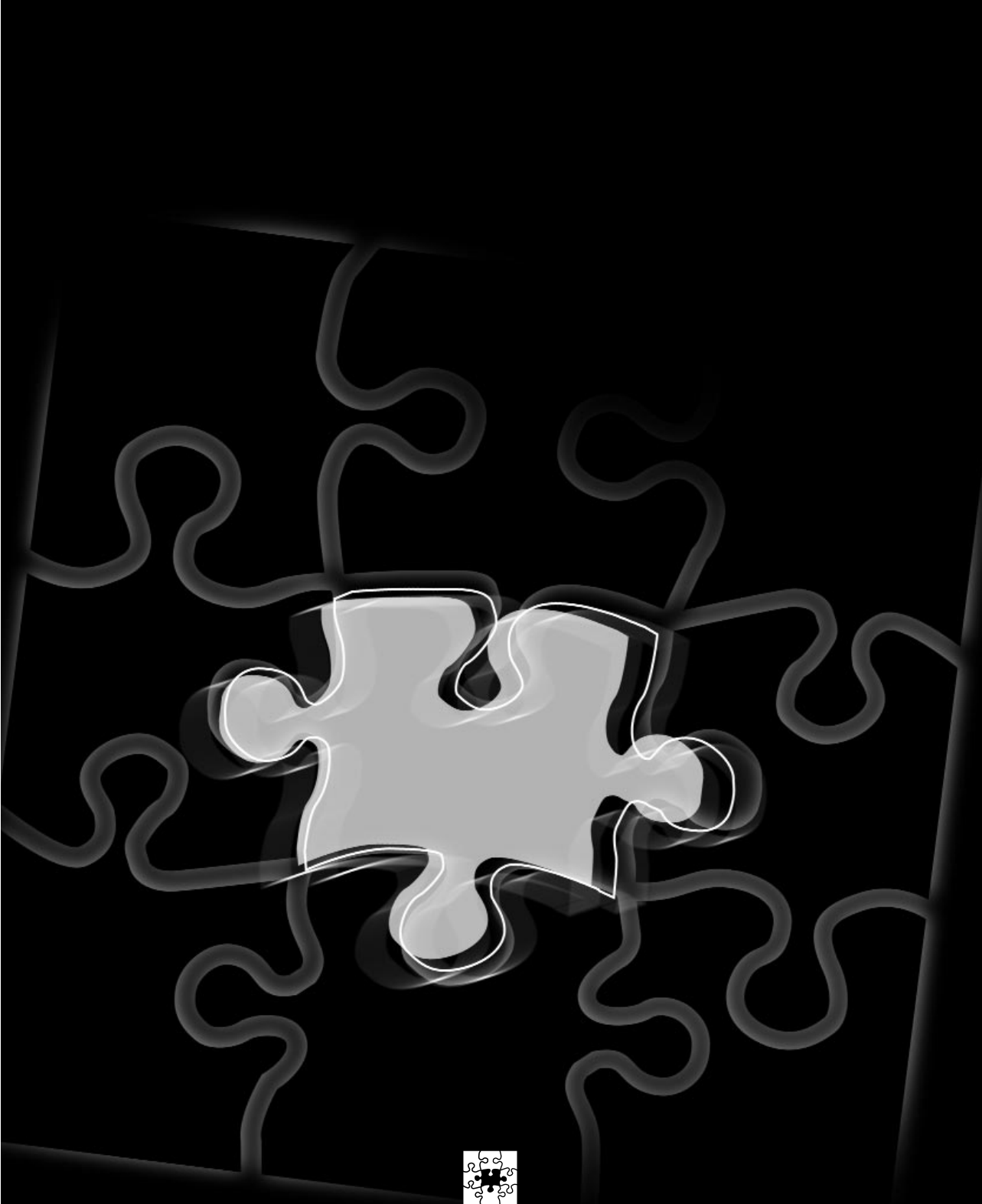
(PH.D. STUDENT, STRUCTURING ELECTRONIC INFORMATION)

MAARTEN DE RIJKE

(PROJECT LEADER 'COMPUTATIONAL LOGIC')

YDE VENEMA

(PROJECT LEADER 'LOGIC IN COMMUNICATION')



INSTITUTE FOR LOGIC,
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