Knowledge, chance, and change
Kooi, Barteld Pieter

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2003

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

Copyright
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

Take-down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Download date: 24-08-2019
RIJKSUNIVERSITEIT GRONINGEN

KNOWLEDGE, CHANCE, AND CHANGE

PROEFSCHRIFT

ter verkrijging van het doctoraat in de
Wiskunde en Natuurwetenschappen
aan de Rijksuniversiteit Groningen
op gezag van de
Rector Magnificus, dr. F. Zwarts,
in het openbaar te verdedigen op
vrijdag 5 september 2003
om 16.00 uur

door

Barteld Pieter Kooi

geboren op 28 augustus 1976
te Groningen
Promotor: prof. dr. G.R. Renardel de Lavalette
Co-promotor: dr. L.C. Verbrugge

Beoordelingscommissie: prof. dr. J.F.A.K. van Benthem
prof. dr. W. van der Hoek
prof. dr. E.C.W. Krabbe
 Contents

Acknowledgments ix

1 Introduction 1

2 Epistemic logic 3
   2.1 Introduction ............................................. 3
   2.2 Language and semantics ................................. 3
   2.3 Proof systems ............................................. 6
   2.4 General and common knowledge .......................... 7
   2.5 Bisimulation .............................................. 8

3 Strong completeness and disharmony 11
   3.1 Introduction ............................................. 11
   3.2 The infinitary proof system PDLω ....................... 12
   3.3 Strong completeness: the canonical model for PDLω .. 16
   3.4 Generalization to other modal logics ................. 19
       3.4.1 Epistemic logic ....................................... 21
   3.5 Comparison to other work ................................ 23
   3.6 Program (dis)harmony ................................. 25
   3.7 Conclusion ............................................... 32

4 Information change 33
   4.1 Introduction ............................................. 33
       4.1.1 Muddy children ....................................... 35
       4.1.2 Byzantine generals ................................. 36
       4.1.3 Sum and product .................................... 37
       4.1.4 Chedo ............................................... 38
       4.1.5 Lecture or Amsterdam .............................. 38
   4.2 Multi-agent systems ...................................... 39
4.3 Dynamic epistemic logic ................................................. 42
  4.3.1 Updating with programs ......................................... 43
  4.3.2 Learning to preserve S5 ......................................... 47
  4.3.3 Epistemic actions ................................................ 50
  4.3.4 Changing modalities .............................................. 56
4.4 From action terms to action sentences .............................. 58
  4.4.1 Action language .................................................. 59
  4.4.2 Dyadic hybrid epistemic logic ................................. 69
4.5 Where do we go? ...................................................... 74

5 Intensional and statistical probability ................................. 77
  5.1 Introduction .................................................................. 77
  5.2 Languages and Models ................................................ 80
    5.2.1 The intensional probability logic IPL ........................ 80
    5.2.2 The statistical probability logic SPL ......................... 82
  5.3 The relation between IPL and SPL .................................. 84
  5.4 The probabilistic epistemic logic PEL .............................. 86
    5.4.1 Language and semantics ....................................... 86
    5.4.2 Sample space assignments ..................................... 88
    5.4.3 The generalized statistical probability logic GSPL .......... 90
  5.5 Toward correspondence theory for probability logics .......... 94
    5.5.1 Correspondences ............................................... 95
    5.5.2 Complexity .................................................... 97
  5.6 Conclusion ................................................................ 97

6 Probabilistic dynamic epistemic logic ................................ 99
  6.1 Introduction .......................................................... 99
  6.2 Motivation ............................................................ 99
  6.3 Language and semantics .............................................. 101
  6.4 Reasoning about probability ........................................ 105
    6.4.1 Building a Model ............................................... 105
    6.4.2 Proof system, soundness and completeness ................ 108
  6.5 Bisimulation for probabilistic dynamic epistemic logic ....... 114
  6.6 Example .................................................................. 118
  6.7 Conclusion and further research ................................... 119

7 The Monty Hall dilemma ................................................. 121
  7.1 Introduction .......................................................... 121
  7.2 A semantical analysis ............................................... 123
  7.3 A syntactic analysis .................................................. 125
  7.4 Conclusion ............................................................ 128
## Table of Contents

8 Mastermind ................................................. 129
  8.1 Introduction ........................................... 129
  8.2 Game theoretic analysis ............................... 130
  8.3 A simple strategy ..................................... 131
  8.4 Looking one step ahead ............................... 131
  8.5 Empirical results ..................................... 136
  8.6 Evaluation ............................................. 137
  8.7 Conclusion ........................................... 140

9 Trying to resolve the two-envelope problem .......... 141
  9.1 Introduction ........................................... 141
  9.2 A purely logical paradox ............................. 143
  9.3 The two-envelope paradox ............................ 146
  9.4 The two-envelope problem ............................. 146

10 Conclusion ................................................ 149

Samenvatting ................................................. 153

Bibliography ................................................. 156

Index ............................................................. 169
Acknowledgments

I thank Gerard Renardel for giving me the opportunity to write this thesis and his supervision. His door was always open if I wanted to discuss something. I thank Rineke Verbrugge for her supervision, which she always made time for despite the growing pressures of her busy job. I thank both of them for doing research with me on strong completeness and disharmony.

I thank Johan van Benthem for his support, for his suggestions, for his invitation to Stanford, and his interest in my work during the past four years. I thank Wiebe van der Hoek for his support, for his suggestions, for the detailed comments he wrote as a member of the reading committee, for doing research together, for his invitation to Liverpool, and for the wonderful times in Great Britain and New Zealand. I thank Erik Krabbe for his very detailed comments on the manuscript he provided as a member of the reading committee.

I thank Hans van Ditmarsch for his support during the past four years, for traveling around the world and inviting me to all the places he went, especially for inviting me to New Zealand, where I finished the first complete version of the manuscript (thanks to his encouragements), for doing research with me, and most of all for being a wonderful friend.

I thank the Netherlands Organisation for Scientific Research (NWO) and the Institute for Mathematics and Computing Science of the University of Groningen (IWI) for their financial support for my trip to New Zealand.

I thank Casper Albers and Willem Schaafsma for doing research with me on the two-envelope paradox.

I thank Robert van Rooy for doing research on questions with me and for trying to make a special issue with me.

I thank Roland Auer, Wim Hesselink, Erik Krabbe, Theo Kuipers, Wim Oudshoorn, Jeanne Peijnenburg, Jan Willem Romeyn for their comments on papers that later became parts of this thesis.

I thank Macht Berkenbosch, Edith Coenen, Dirk Jan Kort, Esther Moet, Lucjan Muresan, and Simon Plantinga for being wonderful roommates.
I thank Roland Auer, Maint Berkenbosch, Henk Bruin, Robert Carls, Marc Dröge, Aletta Eikelboom, Joost le Feber, Geert Fekken, Jeroen Gerrits, Hendrik Wietze de Haan, Gert Jan van der Heiden, Theresa Helmholt-Kleefsman, Jun Hoo, Remke Kloosterman, Robert Kuik, Nico Kruithof, Erwin Loots, Theo Dirk Meijs, Arie de Niet, Martijn van Noort, Conny Pott, Marius van der Put, Lenny Taelman, Ena Tiesinga, Jaap Top, Evgeny Verbitskiy, and Peter Zwerver for lunches, tea breaks, and other breaks at the IWI. I thank Willem Labuschagne for coffee breaks, and lunches in Dunedin where we had some wonderful discussions.

I thank Joost le Feber, Hendrik Wietze de Haan, Wim Hesselinck, Jan Jongejan, Jan Eppo Jonker, Conny Pott, Gerard Renardel, Jan Terlouw, for the weekly meetings of the Fundamental Computing group and for the occasional stroopwafel that was served during these meetings.

I thank Alle Meije Wink for co-organizing the AI0 colloquium. I thank Jan Albert van Laar for co-organizing the golog lectures.

I thank Gerlof Bouma, Taeda Jocić, Erik Kрабб, Theo Kuipers, Jan Albert van Laar, Fiore Nicolai, Anna Pilatova, Gerard Renardel, Wouter Teepe, Jan Willem Romeyn, Rinke Verbrugge for the existence of golog.

I thank Peter Arendz, Annemieke Beerenboom, Jurjen Bokma, Esme Elshof, Desiree Hansen, Ineke Kruizinga, and Harm Paas for their technical and moral support.

I thank Fiona Douma and Theo de Vries for the inspiration the supervision of their master theses gave me.

I thank Boulevard van Bruin, Balder ten Cate, Francien Dechesne, Paul Dekker, Sjoerd Druiven, Paul Harrestein, Ronja Mastop, Marc Pauly, and Robert van Rooy for being great company at many ILLC, OZSL, and related events.

I thank Harm Bakker, Jur van den Berg, Jasper de Boer, Meinte Boersma, Hendrik Wietze de Haan, Anton Jansen, Jan Eppo Jonker, Arend Snijt for the great times organizing the IWI programming contests in 2002 and 2003.

I thank my friends for great times.

I thank my parents, and my brother for their love and support.

I thank everyone I forgot to mention above to whom I owe gratitude for not being offended by that.

Barteld P. Kooi
Groningen, July 2003