My Logical Journey

(Still unfinished, luckily!)

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Thanks & Acknowledgments

- First, I want to thank for this award to the Members of the **Jury of the Dov Gabbay Prize**, and its Chair **Philip Welch**!
- I also thank to the **Initiative for Logic and Foundation (ILOAF)**, and its President **Emil Weydert**, for installing this award.
- I thank **Johan van Benthem** for giving the beautiful **Laudatio**!
- And, most importantly, thank **Dov Gabbay** for not only inspiring this Prize, but for being an inspiration to me and logicians everywhere, through his extraordinary prolific and deep, interdisciplinary work at the interface of Logic with... well, everything else!

Thanks & Acknowledgments – continued

- I want to thank **my collaborators and co-authors** (some of whom I will name later), for making my work possible: Logic is a group activity!
- I thank to the **many people who inspired and influenced my logic journey** (even if I didn't actually co-author with most of them), and in particular to: my Phd supervisors **Jon Barwise** and **Larry Moss**; **Johan van Benthem**; **Samson Abramsky**; **Mike Dunn**; **Rohit Parikh**; **Sergei Artemov**; **Kevin Kelly**; **Jan van Eijck**; **Jouko Vaananen**; **Gabriel Sandu**; **Jan Rutten**; and once again (-last, but not least) **Dov Gabbay**.
- Finally, I want to **thank you all** for attending this event!

Themes, Topics and Threads throughout My Work

1. "Dynamic Epistemology" and its Logic
2. Paradoxes, Circularity and Self-Referentiality
3. Epistemic Topology and Topological Epistemology
4. Foundations of Quantum Mechanics and Logics for Quantum Information
5. Rationality and Action in Game Theory
6. Non-Omniscient Agents and the Dynamics of Justification
7. Probabilistic Learning & Its Logic
8. Logic of Dependence, Correlations & Causality
9. Others.

1. “Dynamic Epistemology” and its Logic

- **Dynamics as the core of epistemology**, and the key ingredient in its logical formalization: **static epistemic attitudes are meaningful in the view of their (past, future, potential or counterfactual) dynamics**.
- **Taking epistemic (inter)actions seriously, as first-class citizens**: use **epistemic/doxastic event models**, consisting of **possible events** (-besides the usual possible-worlds models). Cf. work with Larry Moss and Slawomir Solecki; and later with Sonja Smets.
- **Towards an ‘Erlangen Program for Epistemology’**: **epistemic/doxastic transformations are fundamental**; the interesting static attitudes are the ones **preserved** by (the appropriate) transformations: **fixed points, stability, indefeasibility, sensitivity, convergence, margin for error**.
- Instead of fruitlessly hunting for the “best” definition of knowledge, focus on **epistemic activities** as **truth-oriented, self-correcting, ’convergent’ forms of belief change**.

Dynamic Epistemology – continued

- **Epistemic Dynamics is Question-guided & Goal-directed**: formalize the agents' **interrogative agendas**, that guide belief change, and shape and structure (and restrict) knowledge. **Only question-relevant information is 'known'**. Changing the questions: **interrogative dynamics as paradigm change**. Work with my students Rachel Boddy (together with S. Smets) & Wessel Kroon.
- **Social Epistemology must be irreducibly dynamic and interactive**. Since groups don't have mental states, their epistemic power can only be assessed in the view of **their potential for coordinated action**, or else through their **actualization within individuals** (via actions such as **communication, deliberation, argumentation, voting** etc). Work with J. Hansen, S.R. Rad, J. Sack & S. Smets, and our students Andreea Achimescu, Gaia Belardinelli, Rachel Boddy, Zoe Christoff, Roosmarijn Goldbach, Klarise Marais, Rasmus Rendsvig, Suzanne van Wijk).

2. Paradoxes & 'Virtuous' Circularity

General idea: most paradoxes involve **interesting forms of circularity and 'negative loops'**. These constitute a **resource** that can be **exploited** (rather than simply "solved" and eliminated). **The best 'solutions' are the ones that live "at the border of paradox"**: they keep the essential "paradoxicality", putting it to work in revealing deeper phenomena.

- **Paradoxes in Set Theory**

  At one level, the Burali-Forti paradox shows that the class *On* of all ordinals is **not a set** (and thus, not an ordinal). But in Modal/Topological Set Theory, it also shows that the smallest **set** that includes all ordinals is a **"paradoxical ordinal" (non-wellfounded and equal to its own successor)**:

$$\Omega = On \cup \{\Omega\}.$$

  On and Ω are **observationally equivalent**: they satisfy the same (infinitary) modal formulas.

Paradoxes – continued

- **Semantical Paradoxes**: the "Coinductive Theory of Truth" proceeds by **unravelling/observing reality coinductively** (as in e.g., **Game Semantics**), rather than building it inductively (as in Correspondence Theory). **No need to assume that reality is well-founded**: there may be **no ultimate level**!
- **Epistemic 'Paradoxes'**: At one level, the Surprise Exam Puzzle shows that self-referential statements about (that very statement's) future doxastic effects **cannot be infallibly true**. One can still adopt a 'soft' positive attitude: **be willing to believe them**, unless proven false. But **this will make them false** (and known to be so)! Paradox?! No, but close enough!
- **Social-Epistemological 'Paradoxes'**: informational cascades, the Curse of the Committee, pluralistic ignorance, etc.
- **Game-Theoretical 'Paradoxes'**: the dynamic treatment of the Backward Induction Paradox.
- **Quantum-Theoretical Paradoxes**: multi-agent quantum paradoxes (Wigner, FR) appear to 'break' epistemic principles.

3. Epistemic Topology

Two uses of Topology to model evidence and justification:

(I) **The topology of potential evidence**:

- work with Nina Gierasimczuk and Sonja Smets on **learning, the universality of AGM learning** (and other belief-revision methods), and the **topological Ockham's Razor**;
- **logics for learning**, in work with my student Ana-Lucia Vargas (together with Aybuke Ozgun, Nina & Sonja);
- work with David Fernandez-Duque and Nick Bezhanishvili on **unknowability & topological Surprise Exam**, and its relations to **Cantor derivative, the perfect core and topological mu-calculus**
- work with J. van Benthem on **continuous (& uniformly continuous) dependence** as **"knowable" dependence**;

Epistemic Topology – continued

(II) **The topology of actual evidence**:

- With A. Ozgun, N. Bezhanishvili and S. Smets on the **evidence-based "dense-interior" semantics for knowledge & belief**, and its use in analysing various Gettier-type phenomena;
- With our students Andreas Occhippinti, Virginie Fiutek & Chenwei Shi (together with S. Smets) on **generalizations of evidence models**;
- Work on **topological group knowledge** with my students Aldo Ramirez, Saul Fernandez (together with N. Bezhanishvili), & Djanira Gomez (together with Malvin Gattinger).
- With my students Kristina Gogoladze and Joris Galema (together with M. Gattinger) on **topological belief bases**.

Other Themes & Topics

[4] Logical Foundations of Quantum Mechanics and Dynamic Logics for Quantum Information

- With S. Smets, some together with K. Kishida, S. Rafiee Rad, J. Sack, and my students Shengyang Zhong & Fei Xue;
- Older work with Bob Coecke and my student Mehrnoosh Sadrzadeh.

[5] Rationality and Action in Game Theory

- With Jonathan Zvesper and S. Smets on a **dynamic analysis of solution concepts** in perfect information games;

[6] Non-Omniscient Agents and the Dynamics of Justification

- With Bryan Renne and S. Smets on developing **Belief-Revision-friendly, "semantically-oriented" versions of Justification Logic**, and applying them to epistemological puzzles.

Other Themes & Topics continued

[7] Probabilistic Learning & Its Logic

- With S. Smets on multi-agent **belief dynamics based on conditional probabilities** (Popper measures);
- With A. Achimescu and S. Sack on **Bayesian DEL**;
- With S. Rad and S. Smets on **learning (imprecise) probabilities** in conditions of radical uncertainty.

[8] Logic of Dependence, Correlations & Causality

- With J. van Benthem on **'simple' logics for functional dependence**, and on the **logic of continuous dependence**
- With my student Dazhu Li (together with J. van Benthem) on **dependence in dynamical systems**
- Recent work on the **dynamic logic of causal interventions**

[9] Others

- With Dag Westerstahl and J. van Benthem on **Compositionality**
- With Hans van Ditmarsch et alia on **Arbitrary Public Announcements**; subsequent work with my student Penelope Economou
- With Julia Ilin and N. Bezhanishvili on the **Logic of Abstraction**
- With my student Giovanni Cinna on **bisimulations for conditional modalities**.

A Surprise Movie!

To end on a light tone, I want to show you a **funny movie**, made by my student Hugo Rennings (as part of his BA thesis in Mathematics), about **the "practical applications" of Topological Epistemology**:

https://www.youtube.com/watch?v=VJy7_vahMP8

You should note that our joint paper (with Aybuke, Nick and Sonja) on the dense-interior semantics hangs on the wall, as a kind of Detective's Instruction Manual!

Enjoy!