

# Logic, Epistemology, and the Unity of Science

# LOGIC, EPISTEMOLOGY, AND THE UNITY OF SCIENCE

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Marie Duží · Bjørn Jespersen · Pavel Materna

# Procedural Semantics for Hyperintensional Logic

Foundations and Applications of  
Transparent Intensional Logic

 Springer

Dr. Marie Duží  
VSB-Technical University Ostrava  
Fac. Electric Engineering and  
Computer Science  
17. listopadu 15  
708 33 Ostrava, Czech Republic  
marie.duzi@vsb.cz  
marie.duzi@gmail.com

Dr. Pavel Materna  
ASCR Praha  
Inst. Philosophy  
Dept. Logic  
Jilská 1  
110 00 Praha 1  
Czech Republic  
maternapavel@seznam.cz  
and  
Masaryk University  
Faculty of Arts  
A. Nováka 1  
Faculty of Informatics  
Botanická 68a  
Brno

Dr. Bjørn Jespersen  
Delft University of Technology  
Fac. Technology, Policy &  
Management  
Jaffalaan 5  
2628 BX Delft  
Netherlands  
b.t.f.jespersen@tbm.tudelft.nl  
and  
VSB-Technical University Ostrava  
Fac. Electric Engineering and  
Computer Science  
17. listopadu 15  
708 33 Ostrava, Czech Republic  
and  
ASCR Prague  
Inst. Philosophy  
Dept. Logic  
Jilská 1  
110 00 Praha 1, Czech Republic  
bjorn.jespersen@gmail.com

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*We wish to dedicate this book to the memory of  
Pavel Tichý*



## Preface

This book is about Transparent Intensional Logic, the brainchild of Pavel Tichý. Three books and around 100 papers on Transparent Intensional Logic have till now seen the light of day since the mid-1960s. So why a book of more than 500 pages now? For two reasons.

Firstly, Transparent Intensional Logic is a theory without something like a textbook. Now this is not an actual textbook, if a textbook is a patient introduction garnished with exercises and solutions; nor is it a teach-yourself-in-a-week manual for the uninitiated-but-curious. But we, the three authors, have striven to write an accessible one-stop survey of Transparent Intensional Logic that may be read by advanced students of logic, semantics, linguistics, informatics, computer science, and kindred disciplines.

Secondly, logical semantics is a field progressing by leaps and bounds, and much has happened since Tichý put out his first and only book in 1988. We thought it was about time for us to assemble in one place the most important extensions, improvements and applications stemming from the last several years that address issues not dealt with either at all or only cursorily by Tichý. We have also made a point of flagging various unsettled issues in the theory's edifice and of indicating the general direction in which we expect solutions are most likely to be found.

This book is, if you like, a snapshot of Transparent Intensional Logic as it looks in early 2010, and makes no claim to being the 'mature', let alone 'ultimate', statement of the theory. If the theory keeps evolving at its current pace, another update will be called for within the next 5–10 years. At the same time, a both methodological and philosophical constraint that is dear to us is that the applications we present should not be ad hoc. Rather they must fall out of an existing theory; and if a particular application calls for amendment of the foundations then it must be thoroughly justified. We like to think of Transparent Intensional Logic as an open-ended theory with a cast-iron core. The execution of the project informing Transparent Intensional Logic—a fully compositional procedural semantics applying indiscriminately to all logico-semantic contexts—is itself an open-ended process.<sup>1</sup>

The book treats of topics familiar from contemporary formal semantics, but devotes special attention to some topics that generally tend to be dealt with only in passing. They include, inter alia, notional attitudes, knowing whether, concepts (understood rigorously and non-mentalistically), attitudes *de re* and anaphora in hyperintensional contexts. Besides, the extensive treatment of anaphora found in this book represents a major step forward for the development of Transparent Intensional Logic, which had so far barely dealt with this linguistic device. The addition opens up new fragments of natural language to analysis. Another vastly

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<sup>1</sup> Of course, the theory's detractors would also want to *execute* the project, but then in the sense of eliminating rather than implementing it.

developed notion would be *requisite*, which underpins our intensional essentialism (in terms of a priori relations-in-extension between intensions). The jewel in the crown, however, must be the extremely detailed and principled elaboration of the *de dicto/de re* dichotomy. The dichotomy is at the heart of Transparent Intensional Logic, because it pretty much does the work that is done by reference shift in most other theories. Without a fully-fledged theory of *de dicto/de re*, the project of a *transparent* intensional logic would remain a pipe dream.

For historical background, Tichý's 1968 paper 'Smysl a procedura' (reprinted as 'Sense and procedure' in Tichý (2004)) marks the inception of Transparent Intensional Logic. There he says that, '[T]he relation between sentences and procedures is of a semantic nature; for sentences are used to record the results of performing particular procedures' (2004, p. 80). Twenty years later he was to publish his critical study of Frege's logic, where his early ideas of procedural semantics and of semantics as being a priori were transformed into an elaborate theory whose *leitmotiv* is the profound and carefully argued conviction that an expression represents 'a definite intellectual journey to an entity' (1988, p. 284). This conviction explains why syntax and semantics are developed in tandem. Transparent Intensional Logic is an interpreted formal syntax (in the shape of its 'language of constructions'), a feature it shares with a proof-theoretic semantics such as Per Martin-Löf's and which sets it apart from a model-theoretic semantics such as Richard Montague's. The simultaneous development of syntax and semantics is one reason why in this book philosophical discussion and technical details are not segregated into entirely separate chapters. Another reason is that Transparent Intensional Logic is a case of philosophical logic, which consists in the application of logical techniques to philosophical problems. Practicing philosophical logic requires continuous coordination between logic and philosophy, and so it would both be inconvenient and contrary to the spirit of the enterprise of philosophical logic to attempt to treat logic and philosophy separately. Logic, as Transparent Intensional Logic understands it, is a calculus, to be sure, but not only. Logic is the noble art of inference, and who wishes to draw valid inferences will need a tool for doing so. This tool is an array of procedures, or instructions or prescriptions, detailing how to proceed when drawing inferences. We identify these procedures with linguistic meanings. Therefore, since this book is about logic it is about semantics.

Tichý began demonstrating the expressive power of Transparent Intensional Logic from the 1970s through the 1990s after emigrating ('defecting', in the parlance of the Czechoslovak Socialist Republic) with his family from Czechoslovakia to New Zealand, where he eventually became Professor of Logic in the University of Otago at Dunedin. In 1974–1976 he worked out a system of atemporal intensional logic based on the simple theory of types, but the manuscript, *Introduction to Intensional Logic*, was not published. The main principles of Transparent Intensional Logic based on the ramified hierarchy of types were laid down in his 1988 monograph, *The Foundations of Frege's Logic*, while demonstrating its puzzle-solving mettle by solving an impressive range of semantic problems in



numerous papers appearing in significant and widely read journals. During Tichý's quarter of a century in New Zealand, as well as after his death in 1994, a group of logicians and philosophers had begun to appreciate the assets and potential of Transparent Intensional Logic and continued working in two directions. Much energy has gone into making the theory more widely known, alerting students and peer researchers to the possibilities offered by Transparent Intensional Logic, both as foundations and applications go. At the same time the theory has seen continued development and application to further topics. Two monographs in English (*Concepts and Objects*, 1998, and *Conceptual Systems*, 2004, both by Pavel Materna), several monographs in Czech and numerous articles in Czech, Slovak and international journals have appeared over the years and contributed to logic, philosophy, linguistics, and computer science.

Two approaches to writing are common. One approach provides a rich background in the shape of discussion, criticism and comparison with kindred and rival theories and makes a minor contribution. The upside is that the selflocation of the new contribution is clear and its virtues explicit. The downside is that the informed reader will have to plough through piles of familiar material before getting to the point. The other, bolder, approach offers generous helpings of new material against a sketched background. The upside is that the informed reader gets to the several new points fairly quickly. The downside of this manner of exposition is that it discharges a good deal of comparative work onto the reader, and perhaps also evokes the impression that the theory were conceived in a conceptual vacuum. We have opted for boldness, though. Our primary goal is to present a particular theory and defend it, while rectifying, amending and expanding it whenever and wherever we saw fit. The comparisons and discussions we have inserted serve both to illustrate our theory better (by describing the less known by the better known) and to demonstrate what we argue to be its superiority.

## Acknowledgments

Writing this book together was fun. It was also rather a workout. Fun the way squash or handball is said to be fun, as Quine once commented after reading David Kaplan's 60-page paper 'Opacity'. We are indebted to a large group of people for stimulating discussions, advice, and encouragement, as well as to institutions for funding along the way. Among our favourite discussion partners are the Slovak logicians and philosophers helping develop TIL, notably Pavel Cmorej, František Gašpár, Marián Zouhar and the Czech researchers Jiří Raclavský and Petr Kuchyňka, both using TIL to solve semantic problems. Moreover, we wish to thank several researchers who are familiar with or even well-versed in TIL without necessarily subscribing to the theory, including Gabriel Sandu, Andrew Holster, Jaroslav Peregrin, Vladimír Svoboda, Petr Kolář, Jan Štěpán and Vladimír Janák. Their questions and objections alerted us to problems which we might have otherwise neglected. It is also interesting to note that TIL—originally developed as a theory within philosophical logic—has turned out to be of particular interest to computer

scientists, not least the members of a team led by Zdenko Staníček as well as some computer linguists, especially Aleš Horák. Marie Duží is grateful to her students Martina Čihalová, Nikola Ciprich, Michal Košinár, Marek Menšík, Jaroslav Müller, and the researchers involved in the Research Laboratory of Intelligent Systems (VSB-Technical University, Ostrava), whose comments contributed to the improvement of the text. Bjørn Jespersen would like to thank several of his colleagues at the Section of Philosophy at Delft University of Technology for their interest in Transparent Intensional Logic, not least Maarten Franssen.

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*Ostrava*  
*Delft, Ostrava, Prague*  
*Prague, Brno*

*Marie Duží*  
*Bjørn Jespersen*  
*Pavel Materna*

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