

## Autoreferat (w języku angielskim – załącznik 2)

### 1. Name and surname

Szymon Frankowski

### 2. Degrees

Master of Philosophy, the theses: *Związek przyczynowy w wybranych systemach filozofii nowożytnej*, (Causal relation in some chosen Modern Philosophical systems), supervision: Prof. Marek Rosiak, University of Łódź, 2002.

PhD in Philosophy, the dissertation *Formalizacja wnioskowań zawodnych* ((Formalization of less-than-certain inferences) supervision: Prof. Marek Nowak, University of Łódź, 2007.

### 3. Employment

Employed as associate professor in Department of Logic, University of Łódź since November 2007 Higher School of Humanities and Economics in Łódź 2003-2009.

The Stefan Batory Higher School of Business in Piotrków Trybunalski 2009-2011.

### 4. The main achievement.

Szymon Frankowski, *Wielowartościowość w logikach modalnych i lingwistyce formalnej* (Many-valuedness in modal logics and formal linguistics). (Wydawnictwo Uniwersytetu Łódzkiego 2016.

#### 4.1 Reviewer of the publisher.

Professor Tomasz Połacik (Silesian University)

#### 4.2 Description

*Many-valuedness in modal logics and formal linguistics* (in Polish: *Wielowartościowość w logikach modalnych i lingwistyce formalnej*) makes an innovative contribution to the area of many-valued modal logics which has been dynamically developed by researchers all over the world representing many disciplines mainly philosophy, mathematics, and computer science. The matters considered in

the book are advanced and pivotal to the investigations on many-valued modal logics and many-valued structures of formal linguistics. The main aim of the work is to present original, so far unknown, results, namely, formal investigations concerning many-valued modal logics and the known linguistics structures in their many-valued approach. As such the book is not a monograph.

The work contains semantical (Kripke) models and syntactical characterization of finitely valued Łukasiewicz modal logics corresponding to different conditions for accessibility relation in Kripke models, such as the following logics:  $K$  (basis modal logic determined by the class of all Kripke models),  $D$  (models with the serial accessibility relation),  $T$  (Kripke models equipped with reflexive accessibility relation),  $4$  (transitive relation),  $B$  (symmetric relation),  $Den$  (dense relation),  $D'$  (relation which is almost serial),  $DC$  (with accessibility relation being a function),  $T'$  (almost reflexive transitive relation),  $4'$  (almost transitive accessibility relation),  $B'$  (almost symmetric accessibility relation). It has been also shown that the combinations of these logics form a very rich (infinite) lattice which is isomorphical to Cartesian product: the lattice of two-valued modal logics and the lattice having the set  $\{2,3,\dots\}$  with the inverse of divisibility relation as a lattice ordering.

Consideration of various properties imposed upon the accessibility relation in Kripke model is of not only formal (combinatorial) importance. In temporal logics these properties stand for time characteristics in the model considered, for instance, the relation of time sequence should be transitive. If  $t_1$  follows  $t_0$ , and  $t_2$  is after  $t_1$ , then  $t_2$  comes after  $t_0$ . From the perspective of Kripke semantics for epistemic logics, the properties of relation embraced by a model render the dependencies between agent's knowledge (cognitive agent) and the reality. For example, reflexivity in such structures means that the structure will become a model for the proposition *If the agent knows that A, then A (occurs).*, i.e. the agent cannot know anything that is not true. The transitivity of such a relation is, in fact, tantamount to a positive introspection – the knowledge of what one knows (*If the agent knows that A then he/she knows that he/she knows that A*)

Of particular importance is the introduction of logic  $RU$  for which no counterpart in any of two-valued logics can be found. It is impossible because this is the first logic that bears the specific character of many-valuedness in Kripke model but is not a mere generalization of the classical (two-valued) construction. At the same time it has been shown that the filtration, which is a well-known method of proving decidability in two-valued modal logic, can be easily adopted to the many-valued case, as well.

But beyond any doubt, the most crucial result of my work is the axiomatization of many-valued propositional dynamic logic. Its importance is warranted by the fact that it can be applied outside logic, mainly in computer science; this logic in its original form describes an execution of a computer program and it can be applied in verification program correctness. The results achieved

and presented in the book can be used in many-valued program checking (artificial intelligence) in an analogous way.

One quite unexpected positive result obtained in the work is that the logic of Nelson can be interpreted in three valued Łukasiewicz logic  $S4_3$  along the same lines as the intuitionistic logic is interpretable in modal Łukasiewicz logic  $S4$ . This fact allows for the extension of the family of translations to the family of all translations between  $n$ -valued models for Nelson logics (or rather their  $n$ -valued counterparts) and the logic  $S4_n$ . Nelson Logic includes a value that falls between two other values, truth and falsity, and whose status remains unknown (undetermined). The value unknown can be assigned to a proposition when there are no sufficient grounds for asserting that it is certainly true or certainly false. This grants the possibility to consider the construction of a logic derived from Nelson logic that would admit degrees of uncertainty about the truth-value of propositions (including more than three logical values). For example, it is not certain that the law of gravity is universal, and we cannot be absolutely sure about the law of supply and demand, however, the degree of uncertainty or instability of the latter seems to be much greater.

Moreover, *Many valuedness in modal logics and formal linguistics* takes a more general approach to many-valuedness in modal logics than it is usually adopted, namely, the values of formulas are valuated in arbitrary lattices. Both, relational and topological, semantics have been presented along these lines; the former draws on the achievements of Melvin Fitting whose investigations, however, were confined to the valuations in Heyting algebras. The significance of the generalization becomes manifest in the context of Heyting algebras considered as the families of agents linked by the relation of *dominance*. So, if an agent  $I$  is dependent in his/her opinion on some other agent  $j$ , then there cannot arise a situation in which an agent  $j$  states that  $A$  is true, and the agent  $I$  does not share his opinion. In the case of Heyting algebra this dependence is a function; but when an arbitrary lattice is considered it can be an arbitrary relation (for example, an agent  $i$  is obligated to state  $A$ , only in the case when  $A$  has been stated by all of the agents he depends on). Finally, last but not least, several set theoretic notions have been defined for many-valued Kripke models, like bisimulation,  $p$ -morphism. These notions have been additionally parametrized by homomorphisms between potentially different lattices that constitute a „valuational base” for Kripke structures.

The results described can be likely applied in the implementation of databases with replication systems wherein the relation *slave-master* between database servers is not a function (i.e. the slave master updates only after agreement of the content of all its master databases).

## 5. Other achievements

### 5.1 Publications (citations without self-citations pointed out in parenthesis)

before PhD:

- 1) *Formalization of Plausible Inference*, Bulletin of the Section of Logic 33/1 (2004) pp. 41-52 (25)
- 2) *p-Consequence Versus q-consequence operations*, Bulletin of the Section of Logic 33/4 (2004) pp.197-207 (5)
- 3) *General Approach to Many Valued Kripke Models*, Bulletin of the Section of Logic 35/1 (2006) pp.11-26 (5)
- 4) *Definable Classes of Many Valued Kripke Frames*, Bulletin of the Section of Logic 35/1 (2006) pp.27-36 (5)

after PhD:

- 5) *Pure Strict Implication Logics*, Bulletin of the Section of Logic 36/1-2 (2007) pp.59-66 (1)

The article contains the proofs of the fact that the logics, R and RT, expressed in implicational language are not finitely axiomatizable.

- 6) *Plausible Reasoning Expressed by p-consequence*, Bulletin of the Section of Logic 37/3-4 (2008) pp. 161-170

As the main result of this paper, there can be indicated the adequacy theorem for two classes of p-logics: (1) based on Łukasiewicz p-matrices and (2) based on p-matrices of Post. It is worth pointing out that the article is the first one to contain the axiomatizations of concrete p-logics. Therefore, it proves the importance of investigations in the area of p-logics and p-consequences, in general (independently defined by many other researchers including Elia Zardini and Robert van Rooij).

- 7) *Bisimulations and p-morphisms*, Bulletin of the Section of Logic (2009) 38/3-4 pp. 229-235

The reduction construction of the notion of bisimulation between two Kripke models (frames), to the conceptually simpler notion of p-morphism has been presented. It has been shown that the essential properties of bisimulation are preserved under this operation (which can be called collasation).

Additionally we indicate that a similar construction can be provided in the case of topological

semantics for modal logics (that is for topological spaces in which topobisimulations can be collapsed into maps being open and continuous). The important feature of collapsation defined in such a manner is its applicability to many-valued Kripke model (however, after an appropriate adaptation). It is worth mentioning that the issue of collapsation has great research capacity (non published results).

8) *Biconsequences*, Logic and Logical Philosophy, Vol. 19 No. 4 (2010) pp. 353–364

This paper is an introduction to the topic of generating new types of consequence operations by the means of disjoint sum operation. Such operations can be used as a metalogical tool for paraconsistent logics developed currently with the impressive impact and speed (Newton da Costa from Brasil, Graham Priest from Australia, and also remarkable Polish logician Stanisław Jaśkowski). Many researchers have great hopes in paraconsistency for its applications in the so called databases tolerating inconsistencies (which does not require coherence condition on data coming from different sources, see Walter Carnielli).

9) *On the Lattice of p-consequences*, Reports on Mathematical Logic No.45 (2010) pp.23-35 **(1)**

The algebraic properties of the family of all p-consequences for a given language has been presented together with a number of properties of the lattice of p-consequences listed; the difference between this lattice and the lattice of consequence has been specified. The article can be seen as a modest contribution into the investigations characteristic for Polish School of Logic (operation of consequence, Ryszard Wójcicki).

10) *Partial and Intuitionistic Logic*, Bulletin of the Section of Logic (2011) 40/3-4 pp. 179-188 **(1)**

The article is focused on the problem of interpretation of the logic determined by Kripke model, consisting of three-valued (partial valuations)  $\vdash_3$  in the fragment of intuitionistic logic, which consists of all formulas having at most one implication only. It provides the proof of the theorem about an equality of codomain of translation of  $\vdash_3$  with the mentioned fragment of intuitionistic logic.

11) *Syntactic Properties of p-consequence*, Logic and Logical Philosophy Vol 20 No 4 (2011) pp.285–295

This is a continuation of the investigations initiated in 1) and 2), and developed in 6) and 9). The extensions of intuitionistic logic **INT**, in the sense of p-consequence, are considered. For any intermediate logic **INT**+ $\alpha$ , defined by addition of an appropriate axiom  $\alpha$  to INT, we consider p-

logic which is defined as a p-consequence version of intuitionistic **INT** emerging from **INT** by adding weak version (in the sense of non-deductivity) axiom  $\langle \alpha, * \rangle$ .

12) *Triconsequences*, Bulletin of the Section of Logic 41/1-2 (2012) pp. 61-70

This is the continuation and extension of the results contained in 8). The disjoint sum of three different operations is considered. They are:

1. p-consequence. An operation corresponding to plausible, non-deductive reasonings.
2. consequence operation of Alfred Tarski. It is a well-known, formal counterpart of deductive reasoning.
3. q-consequence of Grzegorz Malinowski. An operation describing „super deductive” reasoning.

Proof system appropriate for triconsequence (for finitary triconsequences) and semantics (valuational for an arbitrary triconsequence and matrix-like for structural ones) is provided.

13) *About Simulating Polyadic Frames*, Bulletin of the Section of Logic 42/3-4 (2014) pp.203-214

The main purpose of this article is to prove that an arbitrary multimodal logic can be simulated by some logic expressed in the language consisting of, aside from one bimodal operator, only unary operators with at least one nominal variable (derivative from hybrid logic). It is the result similar to the one presented in [GPV] George Gougadze, Carla Piazza, Yde Venema, *Simulating polyadic modal logics by monadic ones*, The Journal of Symbolic Logic, Volume 68, Issue 2 (2003), pp. 419–462. However, the current construction essentially decreases the number of monomodal operators (their number equals  $2 \cdot |O|$ , where  $|O|$  is the cardinality of the set of operators in initial multimodal language) in comparison to [GPV] (where it equals to the total sum of arities of modal operators).

14) *Bisimulations, p-morphisms and BOA*, Proceedings of Trends in Logic XIII, Wydawnictwo Uniwersytetu Łódzkiego 2014.

15) *Expressibility of Many-Valued Linguistics Constructions*, Journal of Applied Computer Science 23/2 (2015) pp.7-19

The article presents simulation of many-valued linguistic structures by the less complex structures: finite automata valuated in BL-algebras by the ordinary ones and probabilistic grammars whose derivations fall within the interval  $[0,1]$  of rational numbers in every essential case.

Moreover, it has been shown that such grammar can be simulated by so called *regularly controlled grammar*.

16) *Wielowartościowość w logikach modalnych i lingwistyce formalnej*. Wydawnictwo Uniwersytetu Łódzkiego 2016.

In 4.2.

The reviewer of international journals:

- 1) Synthese
- 2) Logic and Logical Philosophy
- 3) Studia Logica
- 4) Bulletin of the Section of Logic
- 5) Journal of Applied Non-Classical Logics
- 6) Logica Universalis

Since 2011 invitation to Mathematical Reviews.

Presentations on the conferences:

Trends in Logic IV, Toruń 1-4 September 2006, the title of the speech: *Many Valued Modal Logics*

Non-classical logics – theory and applications, Łódź 4-6 September 2008, the title of the speech: *Plausible reasoning expressed by  $p$ -consequence*

Non-classical logics – theory and applications, Łódź 17-19 September 2009, the title of the speech: *Bisimulations in modal logics*

Applications of Logic in Philosophy and Foundations of Mathematics, Karpacz / Szklarska Poręba 4-7 May 2010, the title of the speech: *Deductive  $p$ -consequences*

Non-classical logics – theory and applications, Toruń 16-18 September 2010, the title of the speech: *Syntactic properties of  $p$ -consequence*

Trends in Logic XIII, Łódź 2-5 lipca 2014, the title of the speech: *Bisimulations,  $p$ -morphisms and BAO*

Non-classical logics – theory and applications, Toruń 26-28 September 2015, the title of the speech:  
*Logic for the spread of disease prevention* (jointly with dr. Michał Zawidzki)

Zastosowania Logiki w filozofii i podstawach matematyki, Szklarska Poręba 9-13 May 2016, the  
title of the speech: *Counting Some Closure Operations*.

Non-classical logics – theory and applications, Łódź 5-7 September 2016, the title of the speech:  
*Many valued propositional dynamic logic*

Participation in Seminar in *Algebra and Logic* conducted by prof.dr.hab. Janusz Czelakowski in  
Department of Foundations of Mathematics of University of Opole in 2003-2010, several speeches:  
*Formalizations of plausible inferences* (in polish: *Formalizacja wnioskowań zawodnych*) (2003), (in  
polish: *Theory of models for many-valued modal logics (Teoria modeli dla wielowartościowych  
logik modalnych)* (2007), *Bisimulations in modal logics* (in polish: *Bisymulacje w logikach  
modalnych*) (2010).

#### International collaboration:

Investigations concerning partial logics with François Lepage (University of Montreal). The results  
were the publications 10) and François Lepage *Partial Probability Functions and Intuitionistic  
Logic* Bulletin of the Section of Logic, 41/3-4 (2012) pp.173-184.

#### Popularizing science:

Since 2011 re-edition and creation of electronic version of the *Bulletin of the Section of Logic*.  
Creation of the Web Page for the BSL and MySQL data base with the searching system based on  
Ajax technology.