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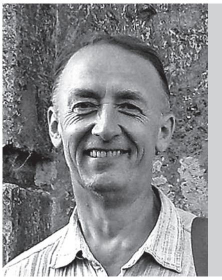
МОДЕЛИ ДЛЯ ФОРМАЛЬНОЙ АКСИОМАТИЧЕСКОЙ ТЕОРИИ ЗНАНИЯ Ξ



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Аннотация

Определяется формальная аксиоматическая теория Ξ, представляющая собой философскую эпистемологию, и исследуется проблема ее логической непротиворечивости. Впервые выносятся на обсуждение такие качественно различные интерпретации аксиоматической системы Ξ, которые являются моделями для Ξ. С помощью этих моделей доказывается, что обсуждаемая формальная теория знания логически непротиворечива.

Ключевые понятия:

формальная-аксиоматическая-теория; эпистемология; интерпретация; модель; непротиворечивость.

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1. Introduction

A definition of the theory Ξ may be found in [15, 19–21]. During the oral presentation and discussion of Ξ at the World Congress on Universal Logic in Vichy, France, 2018, the logic consistency of Ξ was questioned. Moreover, some colleagues expressed the hypothesis that Ξ is inconsistent. Therefore, as in relation to philosophical epistemology, Ξ is a nontrivial novelty worthy of further development and systematical investigation, I have studied the consistency problem and submit results of the study below in this paper.

2. Definition of Ξ

For constructing a rigorous proof of logic consistency of the formal axiomatic epistemology theory Ξ it is indispensable to have a precise definition of that theory.

Therefore, the present paragraph 2 of this paper is aimed at making the reader acquainted with the rigorous formulation of Ξ which can be found, for instance, in [19–21]. According to the definition given in these papers, the logically formalized axiomatic epistemology system Ξ contains all symbols, expressions, formulae, axioms, and inference-rules of the classical propositional logic. Symbols q, p, d, … (called propositional letters) are *elementary* formulae of Ξ. Symbols **α, β, ω, π, …** (belonging to meta-language) stand for any formulae of Ξ. In general, the notion "formulae of Ξ" is defined as follows.

1) All propositional letters q, p, d, … are formulae of Ξ.
2) If **α** and **β** are formulae of Ξ**,** then all such expressions of the object-language of Ξ, which possess logic forms **¬α, (α → β), (α ↔ β), (α & β), (α ∨ β),** are formulae of Ξ as well.
3) If **α** is a formula of Ξ**,** then **Ψα** is a formula of Ξ as well.
4) Successions of symbols (belonging to the alphabet of the object-language of Ξ**)** are formulae of Ξ, only if this is so owing to the above-given items (1) – (3) of the present definition.

The symbol **Ψ** belonging to meta-language stands for any element of the set of modalities {**□, K, A, E, S, T, F, P, Z, G, O, B, U, Y**}. Symbol □ stands for the alethic modality "necessary". Symbols **K, A, E, S, T, F, P, Z**, respectively, stand for modalities "agent *knows* that…", "agent *a-priori knows* that…", "agent *a-posteriori knows* that…", "under some conditions in some space-and-time a person (immediately or by means of some tools) *sensually perceives* (has *sensual verification*) that…", "it is *true* that…", "agent *believes* that…", "it is *provable* that…", "there is *an algorithm* (a machine could be constructed) *for deciding* that…".

Symbols **G, O, B, U**, **Y,** respectively, stand for modalities "it is *(morally) good* that…", "it is *obligatory* that…", "it is *beautiful* that…", "it is *useful* that…", "it is *pleasant* that…". Meanings of the mentioned symbols are defined by the following schemes of own-axioms of epistemology system Ξ which axioms are added to the axioms of classical propositional logic. Schemes of axioms and inference rules of the classical propositional logic are applicable to all formulae of Ξ (including the additional ones).

Axiom scheme AX-1: **Aα → (□β → β).**

Axiom scheme AX-2: **Aα → (□(α → β) → (□α → □β)).**

Axiom scheme AX-3: **Aα ↔ (Kα & (□α & □¬Sα & □(β ↔ Ωβ))).**

Axiom scheme AX-4: **Eα ↔ (Kα & (¬□α ∨ ¬□¬Sα ∨ ¬□(β ↔ Ωβ))).**

In AX-3 and AX-4, the symbol **Ω** (belonging to the meta-language) stands for any element of the set **R** = {**□, K, T, F, P, Z, G, O, B, U, Y**}. Let elements of **R** be called "*perfection*-modalities" or simply "perfections".

3. Models of/for Ξ

Above the axioms of Ξ were defined by the axiom-schemes. Now first of all it is relevant to depart from the meta-language to the object-language, i. e. to move from the above axiom-schemes to the following axioms, respectively.

Axiom AX-1*: **Aq → (□p → p).**

Axiom AX-2*: **Aq → (□(q → p) → (□q → □p)).**

Axiom AX-3*: **Aq ↔ (Kq & (□q & □¬Sq & □(p ↔ □p))).**

Axiom AX-4*: **Eq ↔ (Kq & (¬□q ∨ ¬□¬Sq ∨ ¬□ (p ↔ □p))).**

These axioms are obtained from the corresponding axiom-schemes by substituting: propositional letter **q** for **α**; propositional letter **p** for **β**; □ for **Ω**. In this paper such interpretations of/for **Ξ** are considered in which all the axioms of **Ξ** are true. Now everything is prepared for defining and discussing interpretation-functions to be used for the demonstration of consistency.

Let ⊕ stand for an element of the set of classical binary connectives {→, ↔, &, ∨}. Let @ stand for an element of the set of below-considered interpretation-functions {¥, ∇,€, £}. It is a *common* aspect of the below-given definitions of the interpretation-functions under consideration in this paper that, for any @, ⊕, ω, and π, it is true that:

1) @¬ω = ¬@ω;
2) @ (ω ⊕ π) = (@ω ⊕ @π).

Now let us move to *specific* aspects of the interpretation-function-definitions under review in this paper.

3.1. Interpretation ¥

3) ¥q = true.
4) ¥p = true.
5) ¥Aq = true.
6) ¥Kq = true.
7) ¥Eq = false.
8) ¥Sq = false.
9) For any ω, ¥□ω = true: *everything is necessary*; this is an expression of such an extremely rationalistic a-priori-ism philosophy which can be extracted from writings of Spinoza [28] and Leibniz [11–14].

In the interpretation ¥, all the axioms of **Ξ** are true, consequently, **Ξ** has a model, hence **Ξ** is consistent.

3.2. Interpretation ∇

3) ∇q = true.
4) ∇p = true.
5) ∇Aq = false.
6) ∇Kq = true.
7) ∇Eq = true.
8) ∇Sq = true.
9) For any ω, ∇□ω = false: *nothing is necessary*; this is an expression of such an extreme sensualism-and-empiricism philosophy which can be extracted from writings of Locke [22], Hume [7, 8], Berkeley [5], Mach [23, 24], Popper [26, 27], and Wittgenstein [29].

In the interpretation∇ all the axioms of **Ξ** are true, consequently, **Ξ** has a model, hence **Ξ** is consistent.

3.3. Interpretation €

3) €q = true.

4) €p = true.
5) €Aq = €q.
6) €Kq = €q.
7) €Eq = €¬q.
8) €Sq = €¬q.
9) For any ω, €□ω = €ω.

In the interpretation €, all the axioms of Ξ are true, consequently, Ξ has a model, hence Ξ is consistent.

3.4. Interpretation £

3) £q = true.
4) £p = true.
5) £Aq = £¬q.
6) £Kq = £q.
7) £Eq = £q.
8) £Sq = £q.
9) For any ω, £□ω = £¬ω.

In the interpretation £, all the axioms of Ξ are true, consequently, Ξ has a model, hence Ξ is consistent.

4. Formal proofs of philosophically interesting theorems in Ξ

Strictly speaking, here I mean not proofs of theorems but schemes of proofs of schemes of theorems. They are the following.

4.1. Theorem-scheme (Aα → (Oα ↔ Gα))

Its formal proof (or, strictly speaking, scheme of proofs) in Ξ is the following succession of formulae-schemes.

1) **Aα ↔ (Kα & (□α & □¬Sα & □(β ↔ Ωβ)):** axiom scheme AX-3.
2) **Aα:** assumption.
3) **Kα & □α & ¬□¬Sα & □(β ↔ Ωβ):** from 1 and 2 by propositional logic.
4) **□(β ↔ Ωβ):** from 3 by the rule of &-elimination.
5) **(β ↔ Ωβ):** from 4 by the (limited) rule of □-elimination.
6) **(β ↔ Gβ):** from 5 by substituting **G** for **Ω**.
7) **(β ↔ Oβ):** from 5 by substituting **O** for **Ω**.
8) **(Oβ ↔ β):** from 7 by commutativity of ↔.
9) **(Oβ ↔ Gβ):** from 8 and 6 by transitivity of ↔.
10) **Aα │– (Oβ ↔ Gβ):** by 1–9.
11) **Aα │– (Oα ↔ Gα):** from 10 by substituting **α** for **β**.
12) **│– (Aα → (Oα ↔ Gα)):** from 11 by the rule of introduction of →.

Here you are.

4.2. Theorem-scheme (Aα → (Oα ↔ □α))

Its formal-proof-scheme is the following succession.

1) $\mathbf{A\alpha \leftrightarrow (K\alpha \;\&\; (\Box\alpha \;\&\; \Box\neg S\alpha \;\&\; \Box(\beta \leftrightarrow \Omega\beta))}$**:** axiom scheme AX-3.
2) $\mathbf{A\alpha}$**:** assumption.
3) $\mathbf{K\alpha \;\&\; \Box\alpha \;\&\; \neg\Box\neg S\alpha \;\&\; \Box(\beta \leftrightarrow \Omega\beta)}$**:** from 1 and 2 by propositional logic.
4) $\mathbf{\Box(\beta \leftrightarrow \Omega\beta)}$**:** from 3 by the rule of &-elimination.
5) $\mathbf{(\beta \leftrightarrow \Omega\beta)}$**:** from 4 by the (limited) rule of $\Box$-elimination.
6) $\mathbf{(\beta \leftrightarrow \Box\beta)}$**:** from 5 by substituting $\Box$ for $\mathbf{\Omega}$.
7) $\mathbf{(\beta \leftrightarrow O\beta)}$**:** from 5 by substituting **O** for $\mathbf{\Omega}$.
8) $\mathbf{(O\beta \leftrightarrow \beta)}$**:** from 7 by commutativity of $\leftrightarrow$.
9) $\mathbf{(O\beta \leftrightarrow \Box\beta)}$**:** from 8 and 6 by transitivity of $\leftrightarrow$.
10) $\mathbf{A\alpha \vdash (O\beta \leftrightarrow \Box\beta)}$**:** by 1–9.
11) $\mathbf{A\alpha \vdash (O\alpha \leftrightarrow \Box\alpha)}$**:** from 10 by substituting $\boldsymbol{\alpha}$ for $\boldsymbol{\beta}$.
12) $\mathbf{\vdash (A\alpha \rightarrow (O\alpha \leftrightarrow \Box\alpha))}$**:** from 11 by the rule of introduction of $\rightarrow$.

Here you are.

Obviously, the above-given schemes of proofs are analogous; they are generalized by the following scheme of proofs of scheme of theorems in $\mathbf{\Xi}$.

4.3. Theorem-scheme (Aα → (Σα ↔ Ωα))

For any $\mathbf{\Sigma}$ and $\mathbf{\Omega}$, it is provable in $\mathbf{\Xi}$ that $\mathbf{(A\alpha \rightarrow (\Sigma\alpha \leftrightarrow \Omega\alpha))}$, where the symbols $\mathbf{\Sigma}$ and $\mathbf{\Omega}$ (belonging to the meta-language) stand for any elements of the set $\mathbf{R} = \{\Box, \mathbf{K, T, F, P, Z, G, O, B, U, Y}\}$. (Elements of **R** are called *perfection-modalities.*) The following succession of schemes of formulae is a scheme of proofs of/for $\mathbf{(A\alpha \rightarrow (\Sigma\alpha \leftrightarrow \Omega\alpha))}$ in $\mathbf{\Xi}$.

1) $\mathbf{A\alpha \leftrightarrow (K\alpha \;\&\; (\Box\alpha \;\&\; \Box\neg S\alpha \;\&\; \Box(\beta \leftrightarrow \Omega\beta)))}$**:** axiom scheme AX-3.
2) $\mathbf{A\alpha \rightarrow (K\alpha \;\&\; (\Box\alpha \;\&\; \Box\neg S\alpha \;\&\; \Box(\beta \leftrightarrow \Omega\beta))}$**:** from 1 by the rule of elimination of $\leftrightarrow$.
3) $\mathbf{A\alpha}$: assumption.
4) $\mathbf{(K\alpha \;\&\; (\Box\alpha \;\&\; \Box\neg S\alpha \;\&\; \Box(\beta \leftrightarrow \Omega\beta))}$**:** from 2 and 3 by *modus ponens*.
5) $\mathbf{\Box(\beta \leftrightarrow \Omega\beta)}$**:** from 4 by the rule of elimination of **&**.
6) $\mathbf{(\beta \leftrightarrow \Omega\beta)}$**:** from 5 by the rule of elimination of $\Box$.
7) $\mathbf{(\alpha \leftrightarrow \Sigma\alpha)}$**:** from 6 by substituting ($\boldsymbol{\alpha}$ for $\boldsymbol{\beta}$, and $\mathbf{\Sigma}$ for $\mathbf{\Omega}$).
8) $\mathbf{(\alpha \leftrightarrow \Omega\alpha)}$**:** from 6 by substituting ($\boldsymbol{\alpha}$ for $\boldsymbol{\beta}$).
9) $\mathbf{(\Sigma\alpha \leftrightarrow \alpha)}$**:** from 7 by commutativity of $\leftrightarrow$.
10) $\mathbf{(\Sigma\alpha \leftrightarrow \Omega\alpha)}$**:** from 9 and 8 by transitivity of $\leftrightarrow$.
11) $\mathbf{A\alpha \vdash (\Sigma\alpha \leftrightarrow \Omega\alpha)}$**:** by 1–10.
12) $\mathbf{\vdash A\alpha \rightarrow (\Sigma\alpha \leftrightarrow \Omega\alpha)}$**:** from 11 by the rule of introduction of $\rightarrow$.

From the viewpoint of purely mathematical technique, the proof of $\mathbf{(A\alpha \rightarrow (\Sigma\alpha \leftrightarrow \Omega\alpha))}$ is not interesting (too simple). But from the viewpoint of proper philosophy contents, the statement $\mathbf{(A\alpha \rightarrow (\Sigma\alpha \leftrightarrow \Omega\alpha))}$ is very interesting and important. Various concrete philosophical interpretations (particular cases) of that statement are well-known as fundamental philosophical principles of the rationalism (a-priori-ism). For example, the following specific philosophical interpretations of the theorem-scheme $\mathbf{(A\alpha \rightarrow (\Sigma\alpha \leftrightarrow \Omega\alpha))}$ are worth mentioning.

a) $\mathbf{A\alpha \rightarrow (G\alpha \leftrightarrow T\alpha)}$**:** the rationalistic principle of *optimism in ethics* by N. Malebranche and G. W. Leibniz.

b) **$A\alpha \rightarrow (T\alpha \leftrightarrow P\alpha)$:** the rationalistic principle of *optimism in epistemology* by G.W. Leibniz and D. Hilbert. About modeling this principle see [15; 16; 19].
c) **$A\alpha \rightarrow (P\alpha \leftrightarrow Z\alpha)$:** the rationalistic principle of *mechanistic (algorithmic) optimism in epistemology* by R. Llull (Lullus), G.W. Leibniz, and A.A. Lovelace (Augusta Ada King-Noel, Countess of Lovelace).
d) **$A\alpha \rightarrow (\Box\alpha \leftrightarrow G\alpha)$:** the rationalistic principle of equivalence between necessary being and (universal) goodness. This principle was expressed by some outstanding creators of Ancient-Roman-Law, for example, Ulpian, and some great theologians, for example, St. Tomas Aquinas [1; 2].
e) **$Ap \rightarrow (Gp \leftrightarrow Bp)$:** the principle of *kalokagathia* (Socrates, Xenophon, Plato, Aristotle [2; 3]);
f) **$Ap \rightarrow (Gp \leftrightarrow Up)$:** the principle of *utilitarianism* ethics (J. Bentham, J.-St. Mill [25]).About modeling this principle in Ξ, see [17; 19].
g) **$Ap \rightarrow (Gp \leftrightarrow Yp)$:** the principle of *hedonism* ethics (Aristippus, Epicurus). Modeling this principle in Ξ is discussed in [17; 19].
h) **$Ap \rightarrow (Bp \leftrightarrow Yp)$:** the principle of *hedonism in aesthetics*;
i) **$Ap \rightarrow (Bp \leftrightarrow Up)$:** the principle of *beauty of useful* (and *usefulness of beauty*).
j) **$Ap \rightarrow (Tp \leftrightarrow Up)$:** the principle of *pragmatism* in theory of truth (J. Dewey [6], W. James [9; 10], C.S. Peirce).
k) **$Ap \rightarrow (Tp \leftrightarrow Bp)$:** the principle of *beauty as criterion of truth*. (W. Blake, P.A.M. Dirac).
l) **$Ap \rightarrow (Pp \leftrightarrow Bp)$:** the principle of *beauty as criterion of proof* (S.S. Averincev).

4.4. Theorem-scheme ($A\alpha \rightarrow (\Box\alpha \leftrightarrow \Box\Omega\alpha)$)

In addition to the above-said it is worth mentioning that the following succession of formula-schemes is a scheme of proofs (in Ξ) of the philosophically interesting theorem-scheme (**$A\alpha \rightarrow (\Box\alpha \leftrightarrow \Box\Omega\alpha)$**), where **$\Omega$** takes values from the set **R**.

1) **$A\alpha \leftrightarrow (K\alpha \;\&\; (\Box\alpha \;\&\; \Box\neg S\alpha \;\&\; \Box(\beta \leftrightarrow \Omega\beta))$:** axiom scheme AX-3.
2) **$A\alpha$:** assumption.
3) **$K\alpha \;\&\; \Box\alpha \;\&\; \neg\Box\neg S\alpha \;\&\; \Box(\beta \leftrightarrow \Omega\beta)$:** from 1 and 2 by propositional logic.
4) **$\Box(\beta \leftrightarrow \Omega\beta)$:** from 3 by the rule of &-elimination.
5) **$\Box(\alpha \leftrightarrow \Omega\alpha)$:** from 4 by substituting **α** for **β.**
6) **$A\alpha \rightarrow (\Box(\alpha \leftrightarrow \beta) \rightarrow (\Box\alpha \leftrightarrow \Box\beta))$:** theorem scheme.
7) **$A\alpha \rightarrow (\Box(\alpha \leftrightarrow \Omega\alpha) \rightarrow (\Box\alpha \leftrightarrow \Box\Omega\alpha))$:** from 6 by substituting **$\Omega\ \alpha$** for **β.**
8) **$\Box(\alpha \leftrightarrow \Omega\alpha) \rightarrow (\Box\alpha \leftrightarrow \Box\Omega\alpha)$:** from 7 and 2 by modus ponens.
9) **$(\Box\alpha \leftrightarrow \Box\Omega\alpha)$:** from 8 and 5 by modus ponens.
10) **$\vdash (A\alpha \rightarrow (\Box\alpha \leftrightarrow \Box\Omega\alpha))$:** by the rule of introduction of $\rightarrow$.

Here you are.

The theorem-scheme (**$A\alpha \rightarrow (\Box\alpha \leftrightarrow \Box\Omega\alpha)$**) may be instantiated by the following nontrivial philosophical principles.

a) **$A\alpha \rightarrow (\Box\alpha \leftrightarrow \Box G\alpha)$:** the natural-law principle of *equivalence of necessary being and necessary positive-moral-value (necessary goodness),* represented in works of Aristotle, Ulpian, and Aquinas. About this see [18; 19].

b) **Ap → (□p ↔ □Op):** the natural-law principle of *equivalence of necessary being and necessary norm (duty),* represented in works of Cicero, I. Kant, and H. Kelsen. Of this principle see [18; 19].

From a) and b) it follows logically that **Ap** → (**□Op** ↔ **□Gα):** the principle of equivalence of the normative (deontic) and the evaluative options of formulating the natural-law doctrine [18; 19].

Gödel's necessitation rule does not belong to the set of inference rules of Ξ. Nevertheless, it is easy to demonstrate in Ξ that *under the condition* that **Aα** (but *not in general*), the following (limited) inference-rule of *necessitation* is valid: "If **Aα |— β**, then **Aα |— □β**". The following inference is a demonstration of this rule.

1. **Aα ↔ (Kα & (□α & □¬Sα & □(β ↔ Ωβ)):** axiom scheme AX-3.
2. **Aα**: assumption.
3. **Kα & □α & ¬□¬Sα & □ (β ↔ Ωβ):** from 1 and 2 by propositional logic.
4. **□(β ↔ Ωβ):** from 3 by the rule of &-elimination.
5. **(β ↔ Ωβ):** from 4 by the (limited) rule of □-elimination.
6. **Aα |— (β ↔ Ωβ):** by 1–5.
7. **Aα |— (β ↔ □β):** from 6 by substituting □ for **Ω**.
8. **Aα |— β**: is given.
9. **Aα |— □β**: from 7 and 8 by propositional logic.
10. If **Aα |— β** then **Aα |— □β**: by 1–9.

5. Conclusion

As there is at least one interpretation in which all axioms of Ξ are true (i. e. a model of/for Ξ exists), Ξ is consistent. Moreover, as all axioms of Ξ are true in both "absolutely opposite" interpretations, namely, the rationalism-a-priori-ism and the sensualism-empiricism ones, the two "opposites" are synthesized by Ξ without a logic contradiction.

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MODELS FOR THE FORMAL AXIOMATIC EPISTEMOLOGY THEORY Ξ

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Annotation

The formal axiomatic theory in question is defined, and the problem of its logic consistency is investigated. For the first time such significantly different interpretations of the axiom system Ξ are submitted which are models of/for Ξ. By means of these models it is demonstrated that the theory in question is consistent.

Key concepts:

formal-axiomatic-theory; epistemology; interpretation; model; consistency.