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On Jan Łukasiewicz's many-valued logic and his criticism of determinism

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Résumé : Dans le présent article, on analyse l'assertion, avancée par Jan Łukasiewicz, que la véracité ou la fausseté des propositions portant sur les événements futurs contingents implique le déterminisme. Pour éviter le déterminisme, il faut, selon Łukasiewicz, rejeter la logique classique (binaire) et remplacer cette logique par la logique polyvalente (trivalente). La conception défendue par Łukasiewicz est examinée en rapport avec la thèse proposée par Susan Haack, selon laquelle la véracité des propositions portant sur les événements futurs n'implique aucun déterminisme. Dans l'article, je démontre que le point de vue de Susan Haack est erroné, car elle ne prend pas en considération toutes les prémisses admises par Łukasiewicz. La prémisses la plus importante concerne la sémantique des verbes du futur. Or, j'essaie de prouver que Łukasiewicz s'appuie sur la sémantique dite peircienne et non ockhamienne. J'essaie de prouver que si on prend en considération la prémisses concernant les verbes du futur, le raisonnement qui a mené Jan Łukasiewicz à créer la logique trivalente s'avère correct.

Dans la dernière partie de l'article, je signale que la logique trivalente proposée par Łukasiewicz pose certaines difficultés et je postule la nécessité de trouver, dans l'avenir, une autre solution du problème de la valeur logique des phrases sur le futur.

Abstract: The article deals with Jan Łukasiewicz's thesis that the truth or falsity of some propositions about the future—future contingents—entails determinism. According to Łukasiewicz, determinism could be avoided by rejecting the classical logic (two-valued logic) and replacing it with many-valued logic (three-valued logic). Łukasiewicz's position is taken under scrutiny from the point of view of Susan Haack's thesis that the truth values of future contingents do not entail any determinism. I argue in the paper that Haack's view is incorrect because it does not take into account all premises accepted by Łukasiewicz. The most important of them concerns the semantics of future verbs. Łukasiewicz, as I try to show, assumes the so called Peircean semantics

and not the Ockhamist one. Next, I try to argue that it is possible to preserve the validity of Łukasiewicz's reasoning which led him to the three-valued logic by taking into account his assumptions regarding the meaning of future verbs. In the last part of my paper, I point out that three-valued logic proposed by Łukasiewicz has some flaws and, therefore, one needs to look for another solution of the problem of future contingents.

In the second edition of his *Aristotle's Syllogistic from the Standpoint of Modern Formal Logic* [Łukasiewicz 1957], Jan Łukasiewicz included a new chapter dedicated to Aristotle's modal syllogistic containing some philosophically crucial remarks concerning logic, in particular, some remarks concerning the role of Aristotle's concept of "bilateral possibility", which had proved especially important for the invention of many-valued logic. Łukasiewicz became aware of the relation between modalities and many-valued logic¹ quite early, and these issues must have been important for him throughout his lifetime since he returned to them, shortly before his death, in the second edition of his masterpiece on syllogistic.

The major aim of my paper is to consider the relation between modalities and many-valuedness in the context of Łukasiewicz's famous criticism of determinism, which he presented in his farewell speech as the Rector of Warsaw University in 1922. As said before, this criticism of determinism must have been essential for him and still correct since he mentioned it again in the second edition of the book dedicated to Aristotle's syllogistic. The relation of these three crucial philosophical ideas, i.e. modality, multivalence and determinism, will be considered in the context of Susan Haack's study of Łukasiewicz's reasoning which led him to the discovery of the three-valued logic. Haack argued that there

1. At the beginning of his logical activity Łukasiewicz tried to build the modal calculus on two-valued logic but he grasped soon that it was not possible because the two-valued system of modal logic based on axioms reporting intuitions regarding modal concepts turned out to be self-contradictory. To avoid contradiction he should have abandoned some of the intuitive axioms capturing our modal intuitions, for example, it could be the axiom based on Aristotle's very intuitive concept of bilateral possibility (it is possible that p and it is possible that non- p). Therefore, Łukasiewicz appealed to many-valued logic; first, to the three-valued logic and later on to the infinitely-many-valued logic. Following Tarski he defined possibility as $Mp = CNpp$ and necessity as $Lp = NCpNp$ but in his essay from 1930 [Łukasiewicz 1930], Łukasiewicz solely pointed out general intuitive conditions which modal calculus should satisfy without having constructed such a system. He presented the axiomatic system of modal logic in 1953 and also gave the four-valued semantic matrix for the logical connectives. It is worthy of noting that all his modal systems were always extensional.

is a logical mistake in Łukasiewicz's reasoning. I will argue, contrary to Haack, that there is no mistake in Łukasiewicz's reasoning provided that it is considered in an adequate context. The essential point for the defense of my position is that Łukasiewicz's criticism of determinism is based on the "Peircean" (as it was dubbed later on by Arthur Prior) and not on the Ockhamist semantics. The Peircean semantics is the basis for the so called incompatibility thesis (IT), which says that the future is semantically settled if and only if it is causally settled.² Thus, the defense of IT will contribute significantly to the defense of my thesis that Haack's claim concerning Łukasiewicz's reasoning is false or, to express it in a more moderate way, that Haack's claim is imprecise.

Łukasiewicz's reasoning—the one criticized by Haack—is encapsulated in the following important passage from Łukasiewicz's text:

I can suppose without contradiction that my presence in Warsaw at a definite moment of time of next year, for example, noon of the twenty-first of December, is today decided neither in a positive or a negative sense. It is thus possible, but not necessary, that I shall be in Warsaw at the given time. On this assumption, the assertion, 'I shall be in Warsaw on the twenty-first of December next year' can today be neither true nor false. For if it were today true, then my future presence in Warsaw would have to be necessary, and this contradicts the assumption.

Quoted after [MacCall 1967, 43]³

2. To be more precise, one should say that the future is semantically settled (or it would be even better to say: alethically settled) if it is not causally open. And the future is alethically open at time t with respect to some conceivable future state of affairs X if and only if for some future time t^* neither " X will obtain at t^* " nor " X will not obtain at t^* is true at t " [Rhoda 2007, 303]. The future is causally open with respect to state of affairs X , present time t , and future time t^* if and only if, given all that exists as of t , it is really possible both that X obtains at t^* and that X does not obtain at t^* [Rhoda 2007, 302]. Thus, alethic openness and causal settledness are incompatible, and hence the name 'incompatibility thesis' (IT).

3. Łukasiewicz's argument for fatalism was inspired by Aristotle's reasoning from *De Interpretatione* 9. Therefore, Aristotle's reasoning is worth quoting in detail: "If a thing is white now, it was true before to say that it would be white, so that of anything that has taken place, it was always true to say 'it is' or 'it will be'. But if it was always true to say that a thing is or will be, it is not possible that it should not be or not come to be, and when a thing cannot not come to be, it is impossible that it should not come to be, and when it is impossible that it should not come to be, it must come to be. All then, that is about to be must of necessity take place. It results from this that nothing is uncertain or fortuitous, for if it were fortuitous, it would not be necessary". *De Int.* 18b 10–16. After [Priest 2008, 251–252].

According to Haack, Łukasiewicz's argument is not valid [Haack 1978].⁴ In order to make clear why she regards Łukasiewicz's argument as unsatisfactory, I propose a very brief reconstruction of her putative view below.

Let z be 'I shall be in Warsaw on the twenty-first of December next year'. Then Łukasiewicz's reasoning goes as follows:

- (1) It is necessary that if it is true now that z will be the case, then z will be the case.
- (2) It is true now that z will be the case. Hence:
- (3) It is necessary that z will be the case.

The premise (1) is intuitively true but the reasoning is, as Susan Haack claims, a kind of modal paradox (modal fallacy: passing from $L(A \rightarrow B)$ to $(A \rightarrow LB)$).

The problem, according to Łukasiewicz himself, arises under the intuitive assumption made by him and based upon bilateral possibility: state of affairs (or event) z may obtain and z may not obtain. But if it is true that z will obtain before z obtains, then z is necessary, and not possible (contingent), which is in contradiction with the assumption; and if it is false that z will obtain before z does not obtain, then z is impossible, which is in contradiction with the assumption that z is possible.

If Haack is right, then there is no logical inference between the subsequence: "It is true today that z will obtain" in the conditional: "If it is true today that z will obtain, then z is necessary" and the consequent " z is necessary". The truth of the future-proposition does not entail the necessity of the future. There is no danger of fatalism which Łukasiewicz wanted to avoid, and, hence, there is no need to make a revision of the classical logic by rejecting the principle of bivalence. Thus, the basic

4. In Haack's opinion, Łukasiewicz's reasoning is based upon the formula: $L(A \rightarrow B) \rightarrow (A \rightarrow LB)$. The objection raised by Haack against Łukasiewicz's reasoning would be that the necessity of consequence does not imply the necessity of the consequent. However, the proposition: "if it were today true, then my future presence in Warsaw would have to be necessary" or formally: 'if A then necessarily B ' is ambiguous [Priest 2008, 132]. It could mean $L(A \rightarrow B)$, as Haack suggests, or $(A \rightarrow LB)$. If 'if A then necessarily B ' is taken in the first sense, then the premise $L(A \rightarrow B)$ is true but the argument is invalid since LB cannot be inferred from the set of premises: $\{A, L(A \rightarrow B)\}$. If 'if A then necessarily B ' is taken in the second sense, then the argument is valid since it is allowed to infer LB from: $\{A, (A \rightarrow LB)\}$ but there is no reason to believe the conditional $(A \rightarrow LB)$ to be true [Priest 2008, 133]. Thus, regardless of how Łukasiewicz's (in fact Aristotle's) argument is presented, it does not work.

philosophical reason for multivalent logic, i.e. the danger of fatalism under the assumption of the principle of bivalence, disappears.⁵

However, I think that Łukasiewicz's reasoning, whose reconstruction by Haack was based on his utterances from 1930, should be viewed in the context of Łukasiewicz's article "On determinism" [Łukasiewicz 1961], which was prepared on the basis of his speech from 1922, and which was published for the first time in Polish in Łukasiewicz's collected works in 1961, already after his death. It was this article that Łukasiewicz mentioned in the aforesaid philosophical remarks concerning modal logic added to the posthumous second English edition of *Aristotle's Syllogistic from the Standpoint of Modern Formal Logic* [Łukasiewicz 1957]. This chronology, I think, gives evidence that Łukasiewicz never abandoned the ideas expounded in his Rector's speech from 1922. It is highly probable that he held them also when he was formulating his reasoning—analyzed later on by Haack—in the article published for the first time in German in 1930 "Philosophische Bemerkungen zu mehrwertigen Systemen des Aussagenkalküls" [Łukasiewicz 1930], issued then in Polish in 1961, and in English in 1967 as "Philosophical Remarks on Many-valued System of Propositional Logic" in [MacCall 1967]. It is the latter publication that Haack used when formulating her remarks regarding Łukasiewicz's many-valued logic. I suggest that the final conclusion which should be drawn from these historical observations is that Łukasiewicz's reasoning from 1930 is an abbreviated version of his reasoning from 1922.

How do these two versions compare? Before we answer the question, it is recommendable to evoke the most important theses included in the speech by Łukasiewicz from 1922. He took under scrutiny two main arguments for determinism—the view, according to which, if A is b at time t , then it is true at any time prior to t that A is b at t . The first

5. It is worthy of noting, however, that there was another, pure formal, reason for the construction of multivalent logic. Having been acquainted with the matrix based description of the sentential connectives (it took place before the first world war), Łukasiewicz took into consideration the possibility that, instead of two logical values, there would be three logical values in the logical matrix, i.e., "0", "1" and additionally the third logical value "2". Then, however, he could not find any intuitive interpretation for that third logical value "2", and as he confessed, if he had never found such an interpretation, the three-valued logic, and many-valued logic, would have never been constructed (one should add: at least by him), cf. [Łukasiewicz 1998, 243]. A bit later, in 1917, the idea of the third logical value as logical representation of objective possibility became clear for Łukasiewicz, as he reported it in his speech from 1918, and it appeared again in 1920 when he was trying to build the logical matrix characterizing the logical properties of modal propositions. At that time Łukasiewicz introduced again the logical value "2" and called it "possibility" [Woleński 1989, 122].

argument for determinism appeals to the law of the excluded middle, and the second one to the principle of causality. There is no need to present in detail Łukasiewicz's analyses, but one thing is very important for our purposes: Łukasiewicz observed that the two arguments complete each other. In the first argument one uses the linguistic form: "It is true at time t that z " or "It is the case at t that z ". The second argument (from the principle of causality) provides us with the meaning of the form: "It is true at time t that z ". The expression "It is true at time t that z " means: "there exists at time t a cause of z ". Thus, we can conclude that Łukasiewicz accepted the thesis that a proposition about some future event z has the logical value at any time t prior to z (say at time u) if and only if there exists the cause of z at t . However, the last thesis is tantamount to IT, i.e. that the future is semantically settled if and only if it is causally settled. It follows from IT that if there is now no cause of z , then the future tense proposition concerning z is now not true. If, on the other hand, there exists now the cause of z , then z *must* obtain at the future time, say, u , or, in other words, z is causally necessary. The last conclusion follows from the nature of causality: if there is a cause there must be an effect. Thus, the truth of the proposition regarding z at t prior to u is the guarantee of the necessity of z and the causal necessity of z is the guarantee of the truth of the proposition regarding z at t ($t < u$). Let us repeat: if there exists at time t the cause of z , then z is necessary. Therefore, Łukasiewicz's reasoning would be as follows.

- (1) It is necessary that if it is true now that z will be the case, then z will be the case.
- (2') It is necessary that it is true now that z will be the case. Hence:
- (3) It is necessary that z will be the case.

Thus, the reasoning is formally and materially valid, and the thesis of fatalism that the future is necessary provided that future-propositions are semantically settled is valid as well. Therefore, it is not surprising that to avoid fatalism Łukasiewicz had to reject some of the premises of his reasoning.

A critical role in the debate over the future contingency is played by the belief that IT is true. But why could it not be the case that a proposition regarding future is at any time t prior to u (the time of z 's obtaining), i.e., before the future event z occurs, true in spite of the fact that there exists no cause of z at t ? Why can't the truth of future-propositions be grounded in the future events only, but it must be based upon the present (past) state of the world? In other words, what are the reasons for the defense of the Peircean semantics expressed in IT?

It seems that Łukasiewicz did not provide us with a satisfying justification of IT, and he did not consider reasons supporting the Ockhamist semantics that rejects IT.

I think that one should search for an answer to the last question concerning a possible defense of the Peircean semantics in the common language (the second domain of search are the theories of time and truth). This type of defense of the Peircean semantics has been given recently by the proponents of IT, and, since I think that it is in principle correct, I will briefly present the main points of it below. The crucial role here is played by the semantic analysis of verbs in the future tense. Future verbs can have various functions; they can be used in a performative, erotetic and predictive sense. The performative function is exemplified, for example, by the verb *pay back* in the sentence (promise) “I will pay you back”—the sentence expresses a promise of paying a debt. The question: “Will you marry me?” expresses an erotetic force and a desire for some state of affairs to obtain. The predictive function of future verbs is realized in the proposition: “It will rain tomorrow”. It is, however, only the predictive function which is relevant for the justification of IT. The predictive function consists in the expression of a speaker's belief regarding the future that it is now (at the moment of utterance) true [Rhoda, Boyd, & Belt 2006, 443]. The verb occurring in such a role refers to the time which is future in relation to the time of utterance, and that constituent of the verb's meaning which is responsible for the predictive function is called “future temporal force”. The proponents of the Peircean semantics claim that future verbs carry another meaning, or meaning component, called “causal force”. Causal force of future verbs can be deterministic or probabilistic. The proposition: “If you let go of that rock, it will fall” expresses the speaker's belief that there is no possibility that things might turn out otherwise [Rhoda, Boyd, & Belt 2006, 443]. The expressed probability contained in the speaker's belief is 1. But, if a mother warns her child by saying: “Don't go out without your jacket or you will catch a cold” it is not the causal inevitability which she means but only probability, which is less than 1 but greater than 0.

The Peircean argument for the thesis that the future verb carrying predictive function has also causal force is the pragmatic *principle of charity* whose important constituent is the *rule of rational assertibility*. The principle of charity says that one should interpret a person's beliefs in a manner that preserves the rational assertibility of her claims provided that it is allowed by the semantic flexibility and the context of the

utterance. It is important to interpret claims about the world made by a given person at some place and time in the context of her presupposed knowledge. The essential point of the principle of charity is the assumption of rationality of the subject whose utterances are interpreted. Thus, if someone makes claims whose content is not coherent with her knowledge of the world which, as we presuppose, is at the disposal of that person, that claim should not be treated as a serious claim about the world, but rather as a joke, or a lie. But if someone says seriously, for example, that “It will rain tomorrow”, then we are obliged to interpret this sentence in such a way that a given person knows something about the present state of the world which will cause tomorrow rain. Such a person has rational reasons for the belief what will be the case tomorrow. In brief, we attribute a causal force to future verbs used by the speaker in the predictive function by interpreting the speaker’s utterances with the aid of the principle of charity and rational assertibility. If it happens that someone seriously says something about the world (its future state) which is not consistent with the presupposed knowledge of the language user about the world, then that claim should not be interpreted as possessing predictive force. It can happen, for example, that someone playing roulette says that: “The ball will land on 20” (there are 36 possible numbers to be chosen), so the odds are 1 in 36, and, hence, it is more probable that the ball will not land on 20. If we have no evidence that a person making that claim has reasons to believe that the game is, say, “rigged”, then it would be more rational to say that the ball will not land on 20 than that it will. According to the proponents of the Peircean semantics, such an utterance should be construed as an autobiographical claim about the speaker and not as a prediction about the ball. Thus, if a speaker says: “The ball will land on 20”, then he means either: “I’m guessing that the ball lands on 20”, or “I hope the ball lands on 20”, or, for example, “I’m betting on 20”. If this analysis of future verbs is correct, then IT seems to be justified; future tense propositions about future events are now true if and only if there exists now the cause of these future events.

It is worthy of note here that there is an Ockhamist argument against Peircean semantics and IT, and it is also based on the colloquial usage of language. The Ockhamist semantics is a theory of meaning which does not claim that future verbs playing predictive role carry any causal force, their role is predictive only. The reason why it is so is found in the colloquial usage of language when we attribute truth to a sentence about future contingents after things turned out as predicted. Yesterday,

for example, I said: “it will rain tomorrow” and it has turned out today that it is raining. It means, that it was true yesterday that it would rain the next day. The truth of the sentences about future contingents uttered before the future has taken place has its grounds in the future and not in the state of the world at the time when the sentences were uttered. It is the rule “is implies was (will)” (IIWW) which is at work here. However, this rule is not logically obvious, and even, as some proponents of the Peircean semantics argue, it is false. From the fact that we often retrospectively apply the term ‘true’ to propositions about future contingents when the events predicted in them have occurred it does not follow that the propositions were true when they were expressed [Rhoda, Boyd, & Belt 2006, 447]. The only conclusion which can be drawn in such a case is that it was true when a given prediction was made that a predicted event *might* occur but, of course, this is something completely different from saying that it is true that an event *will* occur.

However, such reasoning based upon the colloquial usage of language is not satisfying for someone who resorts to the findings of contemporary linguistics, according to which, it is not the case that there exist future verbs, or even, the very concept of future, in all known languages.⁶ Therefore, in order to defend IT, one should and one can appeal to philosophical arguments which are free from the semantics of colloquial languages. The philosophical argumentation which is meant here relies on the theory of time and the theory of truth, so, it has a metaphysical and epistemological character. It is the so called A theory of time and the classical (correspondence) theory of truth which are meant by the proponents of IT appealing to the philosophical argumentation in defense of IT. The theory of time A (presentism) says that everything that exists is present. All past facts and all future facts exist now or do not exist at all. In opposition to presentism, eternalism maintains that there obtain past facts and future facts and they do not obtain now but the past facts obtain in the past and the future facts obtain in the future. The past and the future are, however, inaccessible for us from the present time. The past and the future obtain outside the present, as completely settled. The correspondence theory of truth says, in turn, that a proposition is true if and only if there obtains a state of affairs posited in the proposi-

6. Of special interest in this respect is Dan Everett's research concerning the Piraha language and culture from the Amazon. The language lacks many features often seen as essential to any human language, such as recursive rules, basic numerals, linguistic resources to express distant future and past, and others, [Sampson, Gil, & Trudgill 2009, 213].

tion. Given that we accept presentism, a proposition is true if there now obtains the posited state of affairs, because if it does not obtain now, it does not obtain at all. Thus, a proposition about future contingents is true now if there obtains a state of affairs posited in that proposition. In other words, the future is contained in the present. But how is it possible? It is possible solely because there exist now the causes of future events, i.e. effects are contained in their causes. Thus, if a proposition about the future is true (is semantically settled), then the future is causally settled, and conversely, but this would mean that IT is true [Rhoda, Boyd, & Belt 2006].

If it were so, then Łukasiewicz's conclusion that the preternity of truth implies fatalism would be correct, and the only way to avoid the fatalistic view would consist in rejecting premises leading to it. Łukasiewicz decided to reject the principle of bivalence or, in other words, to change metalogic. At the beginning of his philosophical activity, after publishing *On the principle of contradiction in Aristotle* in 1910, Łukasiewicz believed, like Tadeusz Kotarbiński, that there is a relation between the law of the excluded middle and determinism. The refutation of determinism would entail the rejection of the law of the excluded middle, i.e. it would be a weakening of the classical logic. However, the revision of metalogic by the rejection of the principle of bivalence and the introduction of the third logical value $\frac{1}{2}$ conceived as objective possibility (or logical indeterminacy) made later on by Łukasiewicz entailed finally both rejection of the law of the excluded middle and the law of contradiction. The solution proposed by Łukasiewicz in his system of the three-valued logic seemed very controversial and was severely criticized. Already in 1938, F. Gosseth, for example, noticed that the formal description of connectives in Łukasiewicz's logic cannot be made coherent with any of the two proposed senses of the third logical value $\frac{1}{2}$, i.e. with the objective possibility or logical indeterminacy [Malinowski 2006, 14]. If we consider two propositions, Gosseth argued, p and $\sim p$, and assume that p is logically undetermined (neither true nor false but the third), then $\sim p$ is also logically undetermined. Therefore, according to the semantic matrix of conjunction fixed by Łukasiewicz for the three-valued logic, the conjunction $p \wedge \sim p$ should also be logically undetermined but it is clearly not very intuitive. It is so because the conjunction $p \wedge \sim p$ is false regardless of the content of p , and, hence, p or $\sim p$ should be false. The similar counterintuitive results arise if we take into consideration the alternative $p \vee \sim p$.⁷

7. To illustrate the last case, let us consider the following example of the alternative: "A woman will be the President of the Republic of Poland in 2020 or a woman

Łukasiewicz mentioned also another possible avoidance of the danger of fatalism in the context of the reasoning considered at the beginning of this paper. If IT is true, then, for example, the propositions: "It is true at time t that John will not be at home tomorrow afternoon" and "It is true at time t that John will be at home tomorrow afternoon" cannot be both true (they are both false) unless there exist at t the causes of John's presence at home tomorrow or John's absence at home tomorrow. The latter situation does not violate the law of the excluded middle because the two considered propositions are not contradictory. While the alternative: "John will be at home tomorrow afternoon or John will not be at home tomorrow afternoon" must be true because either there will exist in the future the causal sequence whose effect will be John's presence at home or there will exist in the future the causal sequence whose effect will be John's absence at home.⁸ This solution, however, did not satisfy Łukasiewicz because it did not take into account the difference between the situation when the proposition: "It is true at time t that John will be at home tomorrow afternoon" is false because there exists now the cause of John's absence at home tomorrow and the situation when it is still an open question what will be tomorrow with John and his presence at his home. It is reasonable only in the first case to take the proposition in question as false. While in regard to the second case it is not allowed and the logical value of the proposition

will not be the President of the Republic of Poland in 2020". This alternative is neither true nor false since both constituents of it do not have any logical value. But there is no other possibility: a woman will be the President of the Republic of Poland in 2020 or a woman will not be the President of the Republic of Poland in 2020. One of the two propositions must be true. If they both were logically undetermined, it could be impossible to attribute falsity to the complex proposition: "A woman will be the President of the Republic of Poland in 2020 and a woman will not be the President of the Republic of Poland in 2020". But, of course, this proposition is false because it is not possible that a woman is the President of the Republic of Poland and is not at one and the same time. The problem of the intuitive interpretation of the three-valued logic was considered many times by various logicians, [Prior 1967], [Borkowski 1977], [Woleński 1990], [Craig 1991], returned to this issue in their writings. Perhaps it is also worthy of note that the controversy over the revision of logic was widely discussed in Poland by the eminent logicians from the circle of Kazimierz Twardowski after publishing *On the principle of contradiction in Aristotle* by Jan Łukasiewicz in regard to the free will-determinism debate at the beginning of the 20th century. Stanisław Leśniewski even tried to prove that logically undetermined propositions are impossible, but finally he was not successful, [Woleński 1990].

8. In his criticism of determinism Łukasiewicz does not reject the principle of causality but the thesis that the causes of the future events exist eternally. According to him, the causes of some future events do not exist now and as long as they do not exist those events are not determined.

is undecided (the proposition is neither accepted nor rejected) and, in consequence, the negation of that proposition: “It is not true at time t that John will be at home tomorrow afternoon” is undecided as well.⁹ Łukasiewicz’s intuition regarding the logical values of these propositions was that they should be captured by the rejection of the principle of bivalence and the introduction of the third logical value—the objective possibility.¹⁰ But, as we said, this solution, in turn, is in conflict with our intuition.¹¹

Summing up, if Susan Haack is wrong and Łukasiewicz’s reasoning analyzed above is valid, and if we keep in mind the critical remarks concerning his way of avoiding fatalism, it is more convenient not to reject the principle of bivalence but to look for another solution.

9. But, if it is so, then also the alternative: “It is true at time t that John will be at home tomorrow afternoon or it is not true at time t that John will be at home tomorrow afternoon” and the conjunction: “It is true at time t that John will be at home tomorrow afternoon and it is not true at time t that John will be at home tomorrow afternoon” are not logically determined, which is not intuitive. The intuition tells us that the conjunction of the two propositions is false, and hence, one of them has to be false, and, therefore, it is not true that they both are neither true nor false.

10. Łukasiewicz was under the direct impact of Aristotle’s remarks included in *De Interpretatione* 9. According to Aristotle’s reasoning, the disjunction: “either a sea fight will take place tomorrow or a sea fight will not take place tomorrow” is now true and necessary, but it is not true now that a sea fight will take place tomorrow or that a sea fight will not take place tomorrow. These propositions concern future contingent events and they are now neither true nor false. Łukasiewicz makes it clear that Aristotle by doing that does not undermine the principle of excluded middle but the principle of bivalence which he formulated himself. Both Stoics and Epicureans understood Aristotle’s teaching in this way. However, it must be said that Łukasiewicz did not take over the already elaborated Aristotle’s views but he made them much more precise. He pointed out that Aristotle himself was not clear and sure enough as to his final view concerning future contingent.

11. Perhaps the conflict would disappear either by changing logical valuation (by a bit different semantic matrix for the sentential connectives than these proposed by Łukasiewicz himself), by extending the three-valued logic to one with more values or by using the technique of supervaluation. According to the last method, the law of the excluded middle holds even though p may be neither true nor false [Priest 2008, 134]. It is also possible to solve the problem by giving up Łukasiewicz’s intuition mentioned above and by maintaining that assertoric propositions about the future are false until the future is settled, and that modal propositions about a future contingent event z : “ z may occur” and “ z may not occur” are both true until the future is settled. Such a proposal has been recently formulated by Boyd, Belt and Rhoda [Rhoda, Boyd, & Belt 2006]. According to their approach, both future tense propositions and future tenseless propositions are false. Thus, two propositions such that one is the negation of the other are not contradictory but logically contrary.

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