
ŁUKASIEWICZ ON CAUSATION

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In 1906, Łukasiewicz published a challenging proposal for the logical treatment of causal relations by means of the concepts of necessity and simple dependence. For this purpose he applied the law of transposition, well known in the propositional logic, combining it with modal considerations (necessity and non-necessity). In my historically motivated analysis of Łukasiewicz's proposal, I suggest that he failed to separate the cause and effect relation from the relation between reasons and consequences, as well as to specify the modalities involved. Nevertheless, Łukasiewicz deserves credit for his pioneering attempt to treat the traditional philosophical problem of causation by the non-traditional means of the logic of relations.

The famous Polish logician Jan Łukasiewicz made many significant contributions to many-valued logics, metalogic, Aristotle's syllogistic, history of logic, etc. Especially at the beginning of his academic career, he was concerned with the traditional philosophical problems as well. A mere glance at the bibliography of his works¹ reveals the proportion of these concerns with respect to purely logical preoccupations which were so significant for his late period, especially for his activities in Ireland. Among his first more extensive philosophical contributions, the paper "The Analysis and Construction of the Notion of Cause"² plays an important role, since it exhibits the roots and background of Łukasiewicz's philosophico-logical efforts that fitted so well into the vivid philosophical atmosphere of Poland at the beginning of the 20th century. Łukasiewicz received his Ph.D. in Lemberg (Lwów) under the leadership of Kazimierz Twardowski, whose antipsychologism in logic and

¹ See *Studia Logica* V (1957), 9-11, and additions in vol. VIII (1958), 63. Also: [10], 307-309. Hereafter this book will be quoted by using the abbreviation ZLF.

² See [8]. This essay was not included into [1].

philosophy not only he shared but also further developed, employing the newest tools of mathematical logic established by Frege, Russell and others.³

The style of [8] is rather traditional, and symbolic procedures are only vaguely outlined, not to speak of the frequent references to old-fashioned figures like Sigwart, Höfler, etc. However, the lines of the treatise anticipate the future discoverer of the idea of many-valued logics, or at least they set him into the proper historical context without which the really important results that were to follow would have been deprived of their pre-history. Obviously, the study of causation has its own intrinsic significance; as an attempt to answer this problem by a confrontation with Hume, Kant, Mill, Schopenhauer and other philosophers, with the logical and metaphysical devices which follow the Aristotelian and scholastic directions.

I. Logical character of causation; causal relation as a binary relation

Before his presentation of logical theory of causation, Łukasiewicz tried carefully to justify his approach, in order to persuade the reader of the legitimacy of the whole procedure. But for a contemporary reader who is acquainted with similar yet later attempts to grasp causation with much more developed logical techniques, Łukasiewicz's points may seem rather naïve. The basic idea, to consider 'causal relation' as a binary relation with 'cause' as its first and 'effect' as its second member, would almost automatically come to the mind of a contemporary student of logic who knows just a little bit about the theory of relations, so extensively developed by Russell, Whitehead, and others. However, Łukasiewicz's essay appeared during the period of the birth of an explicit theory of relations, mediated by the study of polyadic predicates.

Introducing the expression-schema ' ArB ' as representing causal relations in general, Łukasiewicz was forced to be concerned with the following problems:

- (i) What are the members of this relation?
- (ii) What is the relation, denoted by ' r ', itself?

As it can be expected, the problem (ii) is the central one, and its answer will determine the solution of the problem (i). Although the main goal is to

³ In 1907-1908 Łukasiewicz held a series of lectures and seminars on the theory and algebra of relations at the University of Lwów. These were the first lectures on mathematical logic in Poland. See [2], 16.

analyze (construct) the notion of cause, i.e. to clarify the first member of the above causal relation, the decisive step for this consists in the elucidation of the very relation r , particularly in establishing its necessary (or non-necessary) character. In addition, there is an important intuitive consideration which precedes the mere formal account of the causal relation, and which enables the author to state the formal properties of this relation without being bothered too much by the problem (i) (i.e. the members of the relation r , denoted by 'A' and 'B', remain in this stage completely unspecified).

To begin with, causal relation is *irreflexive*, since the cause is understood as being distinct from the effect, and Łukasiewicz would not here accept any metaphysical notion of self-cause, as he was occupied by purely logical definition of causation, ensuing from an empirical (common-sense?) background. Therefore:

a/ not-(ArA)

Then it is not surprising that this relation is also *non-symmetrical* and *transitive*. Thus:

b/ If ArB , then not-(BrA)

c/ If ArB and BrC , then ArC

Transitivity of causation is a basis for the introduction of a technical distinction between direct and indirect cause; since the chains of causal relations are built of progressions (ordered sets) of unspecified objects containing the (relative) first cause and the (relative) last effect.⁴ The difference between finite and infinite series of causes and effects is not stressed. Similarly, the field of causal relation is not characterized as to its finitude or infinitude, and the formal property of *connexivity* (whether for any pair of unspecified objects which belong to that field, the causal relation holds for the pair or its conversion) is not here questioned at all, although it might have clarified the problem of determinism which was one of Łukasiewicz's favorites.⁵

A brief look at causal relation, as a binary relation of a specific kind - the formal properties of which resemble those of the mathematical relation '<' ('less than', 'smaller than') - requires an addition of the feature that is assigned to causal relation by definition:

⁴ At this point, Łukasiewicz avoids any acceptance of the metaphysical conception of an (absolute) first cause, since such a question, despite his admiration of Aristotle's 'first philosophy', would be here considered as irrelevant and unjustified.

⁵ See his paper [9]. This paper was translated into English by Z. Jordan and incorporated into [11], 19-39.

d/ the *correlativity* of cause and effect. This amounts to saying that "Every cause has an effect" and "Every effect has a cause", but only in a logical, not in a metaphysical sense; since an assertion like "Everything has a cause" is not a consequence of this definition but would require a thorough justification. The technically interesting point, whether the members of a causal relation may be *vacuous* (i.e. whether either the cause, or the effect, or both, may be denoted by vacuous expressions which do not refer to anything in reality), remains unnoticed.

Nevertheless, the formal theory of causal relation seems to be here subordinated under the general theory of relations. And there is also another sign of Łukasiewicz's attempt to put the puzzling 'causation' into the net of established logical frameworks. This sign consists in his apparent willingness to use certain valid schemata of propositional logic, connected with the properties of material implication (conditional), for stating the working mechanism of causal relation. And this was done despite the declarations that 'causal relation' (the relation between cause and effect) is not identical with 'consequence relation' (the relation between reason and consequence) as simulated by conditional propositions and/or propositional schemata. This inconsistency will be treated in the next chapter.

II. The law of transposition as a basic pattern for the working mechanism of causal relation

Since the straightforward schema 'If P , then Q ' is only contingently valid (sometimes true, sometimes false, depending upon the substitutions for ' P ' and ' Q '), the logician's desire to possess some basic valid conditional schemata led to the famous MODUS PONENDO PONENS and MODUS TOLLENDO TOLLENS, whether in their tautological or rule (argument-schema) formulation. The discovery of related but non-valid schemata, like the fallacy of affirming the consequent, might have been a natural byproduct of this effort. In general, there has been a search for interesting valid conditional schemata, including the famous paradoxes of material implication or other types of implication.⁶ But the group of four related schemata, due to their transparent and elementary structure, has always, while being used for instructive aims, attracted considerable attention. And it is exactly this group that is employed by Łukasiewicz for characterizing causal relation. To be

⁶ As this process led to questioning the adequacy of representing the entailment (reason – consequence) relation by too liberal material implication. See the attempts of C. I. Lewis, W. Ackermann A. R. Anderson, N. D. Belnap, and others.

more precise, this group was originally used by him for the characterization of the relation of *simple dependence*, under which causal relation is subordinated, as well as for the characterization of the relation of mutual dependence, which is of an equivalence-type and, hence, causal relation cannot fall under it. Here the guiding idea is that of *necessity*, which is to be the most distinguished feature of causal relation, and somehow of the consequence relation as well. Since these are the crucial tenets of Łukasiewicz's conception, the discussion of necessity and dependence, with regard to causal relation, will occupy our attention in the sequel.

The basic, though ambiguous, formula which should characterize causal relation in a definitional way, is:

$$(1) Z = p_1 p_2 + n_2 n_1 + (p_2, p_1) + (n_1, n_2)$$

The letter 'Z' on the left hand side of the equality (or rather equivalence, for its category is propositional) stands for "(causal) connection," in Polish "związek". The symbols ' p_1 ' and ' p_2 ' are propositional variables, while ' n_1 ' and ' n_2 ' stand for 'not- p_1 ' and 'not- p_2 ', respectively. The subformulas at the right side of the equality (equivalence), joined by the ambiguous symbol '+', are built either by a mere juxtaposition of ' p_1 ', ' p_2 ', ' n_1 ', ' n_2 ', by which a necessity is expressed, or they are enclosed in parentheses, the above symbols being separated by a comma, by which a non-necessity is expressed. In addition, ' p_1 ' stands for 'object P_1 has a characteristic c_1 '; ' p_2 ' for 'object P_2 has a characteristic c_2 ', a sign that an analysis into predicates and terms is unavoidable for the adequate grasp of the causal context.

Łukasiewicz reads

' $p_1 p_2$ ' as: 'If P_1 has c_1 , then P_2 must have c_2 ';

' $n_2 n_1$ ' as: 'If P_2 does not have c_2 , then P_1 cannot have c_1 ';

' (p_2, p_1) ' as: 'If P_2 has c_2 , then P_1 need not have c_1 ';

' (n_1, n_2) ' as: 'If P_1 does not have c_1 , then P_2 might not have c_2 '.

It is obvious that the modalities are introduced in some way, but it is not clear whether they: (i) are inserted into the consequent parts of this conditional schema, as Łukasiewicz's reading would suggest, or (ii) enter into the meaning of the tacit connectives that join ' p_1 ' with ' p_2 ', ' n_2 ' with ' n_1 ', etc.; or (iii) are to be prefixed to the respective subformulas. Each of the three possible cases could lead to interesting results. In each case, the causal context seems to be an *intensional* one.

- (1) The consequent of the conditional schema is intensional, which is reflected in the assignments of the truth-values to it. The current sym-

bols representing modalities in modal logics could be here used without any difficulty.

- (2) Here the modalities would affect the conditional connective; be it material implication or something else. Perhaps Łukasiewicz, expressing himself that "the occurrence of the cause produces with necessity the occurrence of the effect"⁷, had in mind some vague idea of strict implication.
- (3) The symbol for modalities would here qualify the entire conditional schema "from outside," in formal opposition to the previous two cases. The above subformulas could thus be read:
 - a. 'It is necessary that if p_1 , then p_2 ', or 'If p_1 , then p_2 ' is necessary'.
 - b. 'It is not necessary that if p_2 , then p_1 ', or 'If p_2 , then p_1 ' is not necessary' (but may be possible), etc.

Nevertheless, this last case (iii) may suggest just the opposite approach to the problem, sacrificing the intensional contexts and modalities completely. Indeed, if we read for example ' p_1p_2 ' as 'If p_1 , then p_2 ' is necessary', then this may mean nothing more than, say, 'If p_1 , then p_2 ' is valid', and hence, in an extensional way, that it is not the case that ' p_1 ' is true yet ' p_2 ' is false. Considering the conventional difference between logical truth (validity in all possible models) and factual truth (validity in some, but not all, possible models), the conditional schema 'If p_1 , then p_2 ' is not a logical, but only a factual (contingent) truth. It is therefore asserted that if 'If p_1 , then p_2 ' is valid, the validity is based here not on logical, but on some extralogical criteria. This fits very well into Łukasiewicz's expectations, because he had emphatically declared the empirical or hypothetical (also: real, probabilistic)⁸ nature of causation.

Thus, if he puts the sign of non-identity between 'causal relation' and 'consequence relation', this is a sound and justified act on his part. Unfortunately, the discussed formula (1) does not seem accurate for this purpose; on the contrary, it invokes a tendency to identify 'causal relation' with 'consequence relation', since the causal relation would formally behave as the consequence relation, due to the fact that the aforementioned quartet of conditional schemata works in the same way for both.

Indeed, if the modalities inserted into the subformulas of the formula (1) are actually read in the extensional way proposed, then they vanish and the bare fact remains that:

⁷ [10], 27 (italics omitted).

⁸ See particularly the sections 4, 10 and 11 of [8]

'If (If p_1 , then p_2), then (If $\sim p_2$, then $\sim p_1$)' is a valid (in all possible models) schema called "the law of transposition"; and if 'If p_1 , then p_2 ' is valid too, but on extralogical grounds, then (due to MODUS PONENS) 'If $\sim p_2$, then $\sim p_1$ ' is valid (on logical grounds).

On the other hand, 'If (If p_1 , then p_2), then (If p_2 , then p_1)' is not valid (in all possible models), but only contingent, etc., etc.

Hence, if the sign '+' in formula (1) is understood as a conjunction sign, from the hypothetical validity of 'If p_1 , then p_2 ', which is the straightforward formulation of a causal relation, the above trio "follows" without difficulties. And this is too little both for the characterization of the consequence relation and of the causal relation. Formula (1) thus exhibits rather an overlap between these two different characteristics, not their differences. On this basis, we could be prone to accept rather the identity between the two relations. Yet this would be contrary to Łukasiewicz's intentions and therefore we have to think about the reintroduction of intensional contexts, or to admit that formula (1) was a failure because the essential characteristics appeared outside the formula, in the informal text. And this could have been interpreted in a double way: as Łukasiewicz's failure only, or as a principal failure, demonstrating the impossibility of adequately "catching" causal relation in logical nets.

The above use of the law of transposition was also responsible for a peculiar feature of Łukasiewicz's idea of causation: his contention that *the effect may sometimes temporally precede the cause*.⁹ Thus it would not be excluded that "a future phenomenon or process produces with necessity a present phenomenon."¹⁰ Yet a closer look at an example which Łukasiewicz offers in support of this view reveals that the possibility of ' n_2n_1 ' is necessary', if ' p_1p_2 ' is necessary' – or 'valid' instead of 'necessary' – makes the whole point. The fact that we can reason in both directions is no ground for reversing the order of causal relation, even if this is done in a negative way. In a later section, Łukasiewicz himself states that he understands under cause and effect "only the *possession* of certain characteristics by a given

⁹ This contention, presented in the section 12 of [8], led to rather confused responses and was later abandoned. Here Łukasiewicz criticizes the Humean notion of 'cause' as "antecedens" and the views which emphasize the simultaneity of the cause and the effect. But the very turning point comes in the discussion of J. S. Mill's words that at least "the effect does not precede /the cause/" (see his [12], 1843; quoted from the London 1911 edition, Book iii, chapter V, section 7).

¹⁰ [10], 41 ([8], section 12).

object, not the nonpossession.”¹¹ However, this is not consistent with his former assertion.

III. The members (field) of causal relation

It is now a time to be concerned with our question (i): What are the members *A* and *B* of the causal relation *r*? The answers will enable us to proceed to the final stage of this essay - to the problems of necessity and dependence.

The members of causal relation are to be *concrete, actual* objects which are not further specified, except in tentatively selected examples. Generally, Łukasiewicz pleads for a metaphysical theory of objects in an Aristotelian or neoscholastic sense, while at the same time attacking the Humean or Kantian psychologism.¹² But the concrete objects are not something amorphous; they can be described by certain characteristics, whether qualitative (properties) or relational. As a good student of contemporary logic, Łukasiewicz appreciates the new results of the theory of relations which are applied in his entire approach to the problem of causation. Therefore a description of these objects exhibits their relational structure which is reflected even in an assignment of a property (non-relational) to the given object (or rather to its substance). Indeed, such an assignment acquires a statement-form '*P* has *c*', where '*P*' is a variable representing any object and '*c*' is a variable representing any characteristic.

To say that a concrete object is a cause of something, or an effect of something, thus means that it possesses one or more characteristics due to which it is a cause, or an effect. The causal connection works then between those objects *via* their distinguished characteristics, and it is not necessarily due to certain changes in them; although we like to detect causation empirically by means of certain observed changes.

An important distinction is here the distinction between *absolute* and *relative* characteristics, which is incidentally also reflected in the terminology ('*a*' for absolute characteristics, '*w*' for relative ones - derived from the Polish word "względny"), though in general formulations, a neutral '*c*' (from the Polish word "cecha") is being used. An object *P* possesses its absolute characteristic *a* of itself, independently of some relation to another object. If it possesses a characteristic *c* only with respect to another, distinct object, then

¹¹ [10], 50 ([8], section 14).

¹² According to him, Hume, Kant, etc. did not know what metaphysics is and they did not know Aristotle. Modern epistemologies and critiques of knowledge have allegedly distorted the genuine philosophy and forgotten its good, scientific traditions.

this c is relative, thus w . As can be expected, the characteristics relevant to causation are relative ones; for an object is a cause (or an effect) only with regard to some other object (reflexivity is excluded).

Unfortunately, there is offered no delineation between absolute and relative characteristics and likewise, how to distinguish concrete, actual objects from abstract ones remains obscure; perhaps this is tacitly considered to be intuitively clear. On the other hand, *abstract* objects are divided into *ideal* (e.g. mathematical or logical) and *real*.¹³

After the clarification of the above issues, the original question (i) may now be answered. The members A and B of causal relation ArB are relations themselves, relations between concrete (actual) objects and their characteristics (absolute or relative properties). Two things must be mentioned here: 1/ a formulation that "cause is a concrete object," and so like, can be only elliptical; 2/ a linguistic representation of such a relation has the statement-category and is non-relational because the above characteristics are represented by monadic predicates. At any rate, the fields of causal relations r seem to be sets of pairs $\{P, c\}$, where P are concrete objects and c their characteristics.

It may be again clear that the original question (ii) is much more important; for here is the clue to the solution of the problem of causation. As it has been already stressed, the tentative solution faces the peculiarities of the concepts of necessity and dependence.

IV. Necessity as an ingredient of causation; simple dependence

Indeed, due to Łukasiewicz, necessity should be the essential ingredient of any causal relation and several other assumed ingredients, traditionally regarded as essential in this respect, are deprived by him of this right. His search for that which makes A the cause of B , i.e. for such a relative characteristic w of the respective P which all the causes share, leads at first to the refusal of: (a) the property of acting, active substance (versus Sigwart),

¹³ See particularly the sections 4 and 10 of [8], where he talks also about the criteria for a correct construction of abstract objects. Consistency or, in negative terms, non-contradiction, is the leading criterion for the ideal abstract objects, while the real abstract objects must also be adequate to the reality and usually require the usage of inductive and experimental methods. It may be worthy to note that Łukasiewicz makes here some points that seem to be *conceptualistic*; despite his apparent inclination to Platonism – or rather to the Aristotelian and scholastic realism – and despite his rejection of any conceptualism which is vitiated by psychologism or "mentalism". Indeed, he identifies concepts with abstract entities, but ambiguously, for at the same time concepts are regarded as *meanings* of expressions *pointing* to the abstract (see the section 2 of [8]).

actual change; (b) temporal precedence or antecedence and contiguity (versus Hume and Mill); (c) regular psychological associations and functional reductionism (against Hume); even of (d) Mill's 'invariability' and 'unconditionality', although this last one comes very close to the point. Finally, necessity wins and so w is to be identified with 'producing or inducing with necessity', as the proposed general property of any causation which makes the relation r what it is. But to say simply that causal relation denoted by ' ArB ' is a necessary relation would not be accurate, because – as Łukasiewicz states – "causal relation is a conglomerate of necessary and non-necessary relations."¹⁴ This can be seen from the formula (1), where the complexity of the relation r is represented by the left-hand side symbol ' Z '.

As the preceding discussion on the extensionality or intensionality of this representation of causal relation exhibits, the word "necessity" is here used in an ambiguous way. The key subformula of (1), i.e. ' p_1p_2 ', which amounts to 'If P_1 has c_1 , then P_2 *must* have c_2 ', is not logically valid under the customary interpretation of 'If ..., then ---'; hence it is not a necessary truth (or analytic in a dogmatic sense). If it were assumed to be logically valid, then it should have been explicitly clarified under what conditions. But, as Łukasiewicz points out, the validity of ' p_1p_2 ' is based on extralogical criteria and thus it is hypothetical, being subject to empirical tests and inductive procedures in general. Subformula ' p_1p_2 ' expresses rather an empirical generalization or, say, a natural law, and so the word "must" indicates perhaps a regularity or uniformity in nature, both physical and mental. Łukasiewicz would have wished to avoid this issue, especially when it comes to admitting something like 'the principle of causality' in this ontologico-epistemological sense.

In his discussion of the relationship between the notions of causation and consistency, he tries to elucidate necessity by the idea of inconsistency in the following way: "an object P must have a characteristic c means that if this object did not have c , it would be inconsistent;" similarly for " P cannot have c ", where the possession of c should lead to inconsistency.¹⁵ Here the polarity of the necessary and the impossible statements, though achieved with the customary help of self-denial, may indicate that 'necessity' is not to be identified with 'analyticity', if 'analytic' means 'logically true' or 'true in all possible models'. Thus there would be two kinds of necessity: logical and physical (empirical).

¹⁴ [10], 28 ([8], section 9).

¹⁵ [10], 31 ([8], section 10; italics omitted).

To be more precise, Łukasiewicz speaks about the whole family of necessary relations which share the same property, and the necessity characteristic for causal relation is distinguished from this family. The relations of that family may be called "relations of *simple dependence*." Actually, the above formula (1) represents something like definition by abstraction of the simple dependence. On the other hand, *mutual* (or complex) *dependence* relation is represented by another formula:

$$(2) Z = p_1p_2 + n_2n_1 + p_2p_1 + n_1n_2,$$

where all subformulas at the right-hand side express necessity.

Translated into the terms of conditions, formula (2) establishes bilateral sufficient and necessary conditions in a form of an equivalence (biconditional), while the formula (1) states unilateral sufficient and necessary conditions in an implicative (conditional) form. The latter is then responsible for the aforementioned troubles with the distinction between causal- and consequence-relation. As previously noted, the very distinction is not revealed from the formula (1), but from an external remark concerning the different fields of the simple dependence relation. The quotation from Łukasiewicz may explain this: "The cause is the first member of a simple dependence relation which /the relation/ matches real objects" (similarly for the effect as the second member of such relation).¹⁶ On the other hand, consequence-relation connects abstract objects, Truth and Falsehood, as assigned to statements. The distinction is thus based on an obscure difference between real and abstract objects and, as such, is in no way convincing.

Nevertheless, the simple dependence relation plays a crucial role and Łukasiewicz has opened the door to its investigation.¹⁷ Today 'simple dependence' is usually defined with the help of the notions of consequence and inconsistency (incompatibility). But in several conceptions, the difference between logical and extra-logical (factual, etc.) dependence is being stressed, and this seems to be relevant to Łukasiewicz's attempts to discern causal and consequence relations through the parallel notions of physical (real, empirical) necessity and logical necessity.¹⁸

¹⁶ [10], 52 ([8], section 15; compare also sections 11 and 13; italics omitted).

¹⁷ In my paper [13], in which inferential, functional and conditional concepts of dependence were distinguished, T. Kotarbiński's results had been praised in this respect. But Kotarbiński (1929) must have taken it from Łukasiewicz.

¹⁸ As to a definition of logical dependence, see e.g. [4], 71, 94, 179-180, 234

V. The definition of causation as an abstract object (concept)

Finally, everything has been prepared for Łukasiewicz's definition of causation or causal relation in general. Since for him causation is a *real abstract* concept (object), an attempt to employ here a certain kind of real definition is not at all surprising. This definition has resulted from a logical construction and analysis of the proper concept. The initial goal of such an analysis has been stated by Łukasiewicz as follows:

"To give a logical analysis of the concept, i.e. of an abstract object, means to find out all its properties and to observe the relations which hold among them, with a particular emphasis on the necessary relations, distinguishing thus the constitutive and the consequential /consecutive/ properties."¹⁹

As to the concept of causation, Łukasiewicz has modified this initial goal, because he observed that: (a) the analysis requires an object to be analyzed, which in the case of causation must first be constructed, though in an empirico-inductive way (the adequacy of this object with respect to reality has to be checked); (b) it is impossible to investigate all properties of this object, especially if we take into account the relative properties. Any distinction we draw between the *constitutive* and the *consequential /consecutive/* characteristics of causation must be based on the selection of the primary characteristics, from which the secondary ones necessarily follow.

Three constitutive and five consequential characteristics are mentioned with regard to causation. The constitutive characteristics are claimed to be mutually independent, and two of them are relative, whereas one is absolute (four consequential characteristics are relative, one is absolute). Altogether the characteristics do not bring anything new, for in them the results of previous discussions have merely been summarized. Thus the first constitutive characteristic is elucidated by the subformula ' p_1p_2 ', the second by ' (p_2p_1) ', and the third (absolute) is "being the actual, real object." The relative consequential characteristics are given, respectively, by ' n_2n_1 ', ' (n_1n_2) ', and the non-symmetry and transitivity of the relation r . The absolute consequential characteristic should follow from the relative ones and is given by our ' $\{P,c\}$ ', which has been phrased by Łukasiewicz as "the relation bearing some characteristics to a given object."²⁰

Afterwards ambiguous definitions of 'cause' follow:

¹⁹ [10], 12 ([8], section 3).

²⁰ [10], 52 ([8], section 15; on this page all the relevant formulations can be found (italics omitted)).

"The cause is a real object which produces with necessity another real object" (but not the other way around).

"The cause is the first member of a simple dependence relation which matches real objects."²¹

These definitions are self-explanatory, at least in the context of previous remarks. The subtle interrelations between the meanings of the terms "causation", "causal relation" and "cause" could be detected from the context of Łukasiewicz's article, though he himself did not pay sufficient attention to them.

I. Future developments

The question of the impact of Łukasiewicz's conception of causation on future philosophical and logical attempts to settle this traditional problem raises special difficulties. His lengthy article of 1906 was published in Polish and apparently only a close circle of philosophers discussed its merits.²² Later on Łukasiewicz seemed to forger, or even abandon, this early work. His reoccupation with the problem of determinism and nonclassical logics led him in a different direction, in which there is no place, for instance, for the temporal reversibility of the cause and the effect. In his famous inaugural address at the University of Warsaw,²³ he gave a more modern account of causation which now should serve as a basis, together with the principle of excluded middle, for solving the problem of logical determinism.²⁴ Here the *transitivity* remains as an essential property of the causal relation, but a pervasive idea comes to the foreground: the striking connection between causation, *infinity* and *continuity*. By establishing a correspondence between sets and subsets of real numbers with the properties of the time-continuum, Łukasiewicz was able to demonstrate that the principle of causation does not

¹ [10], 52 ([8], section 15). Complementary definitions of the 'effect' are also provided here (italics omitted).

² The article was again brought to the attention by the editor of [10], J. Ślupecki, as a historical curiosity (see Ślupecki's introductory words to the volume, pp. 5-8). Among the philosophers who had surrounded Łukasiewicz, Z. Zawirski and T. Czeżowski contributed to the problem of causation; the former in 1912, the latter in 1933. H. Mehlberg published an essay on the causality of time in 1935.

³ Read at the beginning of the academic year 1922-23; but published first in [10], 114-126, under the title "O determinizmie". This paper appeared in English translation, in [11], 19-39. In its defense of free will, Łukasiewicz uses here somewhat different idea of causation.

⁴ See also two articles by Z. Jordan which deal with this problem from the current perspective: [5], 1-38; [7] (here, on pp. 69, 70, 81 and 82, there are direct references to [8]).

support the principle of strict determinism. In other words, the cause of a specific future event need not exist at the present time, but it may well "start" sometimes in the future (definitively preceding the event in question); hence opening an infinite chain of causes and effects, simulated by the corresponding properties of any open interval within the set of real numbers. Thus, both Zeno and Cauchy could have participated in this discussion.

Finally, it is to be noted that this detailed investigation of the Łukasiewicz's conception of 1906 is not intended as a purely historically oriented treatise, nor as a thorough, up-to-date, reconstruction of his position (employing, say, his own later logical symbolism). The goal of this essay is rather to present and preserve the vital line of the great Polish thinker, incorporating into it an early moment of its life, which, nevertheless, honestly ends with the psychologistic traditions of the 19th century and points out to the future trials, represented, for instance, by S. Jaśkowski or A. W. Burks.²⁵

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²⁵ These two authors are mentioned here as perhaps representative in this respect. See [5], 71–92; [3], 363–382.