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J. ŁUKASIEWICZ'S CONCEPTION OF THE CAUSAL RELATION AND CONTEMPORARY CAUSAL LOGIC*

The extensive scholarly achievement of J. Łukasiewicz includes, alongside strictly formalist studies and those devoted to the history of logic, publications concerned with philosophical reflection on systems of logic and logical analyses of some philosophical concepts.

In connection with studies of determinism as well as independently of them he considered the problem of causality [1]. As far as this latter problem is concerned he formulated many valid suggestions concerning the program of solving this problem. However, he did not arrive at the solution itself because he had no unified conception of philosophy. He would speak enthusiastically about Aristotle's metaphysics as about the science of things in general. On other occasions he treated philosophy as the substructure or superstructure of particular sciences [2]. Łukasiewicz did not see clearly enough that classical philosophy can investigate the world in a different aspect than particular sciences. This different aspect determines that which ought to be treated as cause and effect differently in different types of philosophy and the sciences. Depending on the type of knowledge the causal relation may possess different properties and another conception of the nature of some singular features of this relation cannot be excluded. Łukasiewicz's considerations centred mostly around examples taken from physics, the leading science. But the conception of the necessity of the causal relation in physics is treated somewhat philosophically by Łukasiewicz.

Łukasiewicz postulated the deductive method as a way of solving philosophical problems, including the problem of causation [3]. He meant here the use of logical

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[1] J. Łukasiewicz. *O determinizmie* (*On Determinizm*). In: *Z zagadnień logiki i filozofii* (*Problems of Logic and Philosophy*). Warszawa 1961 pp. 114 - 126, and *Analiza i konstrukcja pojęcia przyczyny* (*The Analysis and Construction of the Concept of Cause*). Ibid. pp. 9 - 62.

[2] J. Łukasiewicz, *O logice tradycyjnej* (*On Traditional Logic*). Review of J. Sleszyński, In: *Z zagadnień logiki i filozofii* p. 127 and *Analiza i konstrukcja*→pp. 53 - 55.

[3] J. Łukasiewicz. →*O metodę w filozofii* (*On the Method in Philosophy*), "Przegląd Filozoficzny" 31: 1928 fasc. 1 - 2 pp. 4 - 5.

constants and propositions of the classical logical calculus. Recently new systems, called causal logics, have appeared. These systms do not offer the ultimate solution of the problem of causation but contribute to the precise and intelligible formulation of this problem. They also offer explications of this important concept in philosophy of science. However, it is interesting to note that although the principal studies pertaining to this problem were written at some intervals, they were independent of one another. Here we have in mind the works of such authors as S. Jaśkowski, A. W. Burks, G. H. von Wright. It seems worthwhile to devote some attention to the programmatic assumptions and the results obtained by these logicians in order to arrive at the conclusions concerning the way of constructing causal logic of a certain type

In his article of 1950 Jaśkowski outlined the program of the search for approximative symbolic equivalent of causal expressions[4]. He assumed at the starting point of his investigations that he would extensionalize the causal functions. His program differs from, for example, A. W. Burks' who in his logical system took into account the specificity of causal intensional expressions.

Jaśkowski did not construct the axiomatic system of the logic of causality. However, he pointed to the procedure enabling the construction of the propositions of this logic. In the course of his search for the sentential calculus for contradictory deductive systems, when he was discussing the calculus of modal propositions M_2, he asserted that the propositions of this calculus are expressions consisting, respectively, of apparent sentential variables, functors of propositional logic and the functor of necessity which become the theses of a stricter functional calculus during the application of the operation of replacing apparent variables with corresponding propositional functions and the symbols of necessity with general quantifiers. Analogically, he defined the theses of the system Q, Q_n, Q_f, and $Q+$. Jaśkowski calculus $Q+$ as most important in relation to the problem of causation. However, he does not introduce temporal functors into his system. In defining different symbols in his theory of apparent sentential variables he assumes that each free variable e.g., x_k represents events in some definite time. He stresses that free variables constitute a chronologically ordered sequence $x_1, \ldots, x_n$. In the course of time the earliest arguments are given successively constant values. Thus, the set of possible factors of each sentence diminishes. It can be reduced to $x_k, \ldots, x_n$ free variables.

Jaśkowski considers the situation in which the initial arguments $x_1, \ldots, x_k$ are given, respectively, values $a_1, \ldots, a_k$. Thus, it may happen that the logical value of a given sentence does not depend on the value of variables $x_{k+1}, \ldots, x_n$. Moreover, if the logical value of the sentence p depends on the value of arguments $x_k, \ldots, x_n$, when arguments $x_1, \ldots, x_{k-1}$ have values $a_1 \ldots, a_{k-1}$, Jaśkowski calls argument x_k the efficient factor for sentence p. It is the last significant parameter. Jaśkowski regards the value of this factor as the cause of p (or $\sim p$). It seems that he uses the term

[4] S. Jaśkowski. *On the Modal and Causal Functions in Symbolic Logic*. "Studia Philosophica" 1949/1950 No 4 pp. 71 - 92. A. Pieczkowski referred to Jaśkowski's conceptions.

"cause" in a highly unorthodox way. He does not refer here to an event cognitively conceived and expressed in a sentence which is the cause of another sentence.

In the end Jaśkowski points out that his symbolic apparatus does not suffice for the formalization of any causal expression. He sees a possibility of employing his formalisms primarily in law, although he began with a search for causal logic for natural sciences.

Jaśkowski's article published in English in 1950, had no influence of the works of those authors who are interested in the problem of the formalization of causal laws of physics. Such influence was exerted by Burks' formulations[5]. He attempted to formulate logical laws governing inferences involving causal propositions. He was also interested in the relationship between causal sentences and other propositions. He held that a causal law in physics, transcribed with the help of the general quantifier and material implication, is expressed inadequately. He takes up the analysis of causal propositions in order to find the language to formalize them adequately. As a result of these analyses he intends to specify the meaning of special implication functors which would not be truth-functors. He wants to formulate and justify the theses which are valid for logical constants unknown in the existing systems of logic. In his considerations Burks does not use only the expressions taken from everyday language. He analyzes mainly the causal laws of physics expressed in a qualitative language. Ultimately, he was, unawares, looking for an adequate formal characterization of implication entangled in the causal laws of physics. However, he did not see clearly the specificity of these laws in relation to common expressions alien to physics.

Burks demonstrated a series of propositions which must appear in the system of causal logic. His calculus contains two non-truth implications: counterfactual implication and causal implication. He cleverly took advantage of the inquiry into the interdependencies between relations that are of interest to logicians in order to propose the statements of the logical system under construction. He demonstrated the relationship between the functor of causal implication and the truth functor of material implication. Burks introduced a number of theses of a new logical system when he analyzed the relationships between causal and counterfactual implications on the one hand and strict implication on the other. Propositions of causal logic also involve the appearance of modal functors such as the functor of causal possibility and necessity.

Burks' system of logic has been acknowledged as a pioneering attempt in the search for the logical equivalent of the causal relation. His transcendence of the framework of extensional language is particularly appreciated. However, it seems that causal implication does not render what is essential for the causal relation in physics. For example, Burks did not pay any attention to the fact that the effect follows the cause

[5] A. W. Burks. *The Logic of Causal Propositions*. "Mind" 60: 1951 pp. 363 - 382. Burks' ideas were referred to by, among others, G. P. Henderson, H. A. Simon, A. A. Zinoviev, P. Suppes.

in time in the causal relationship. His thesis that whatever is logically necessary is causally necessary seems doubtful, to say the least. There is yet another inconsequence in Burks' system. In some propositions variables p and q represent simple statements describing events, and in propositions containing symbols of causal possibility and necessity these variables represent certain conditionals.

Formal analysis of the causal relation has been taken up also by G. H. von Wright [6]. His study of causal relations begins with a construction of a certain model of the world. He points out that in terms of logic the real world can be analogical to this construct. He assumes in his formal analyses the system of tense-logic which he has constructed. He proceeds differently only in relation to modal logic. He considers at length the justification of the choice of a certain modal logic for the analysis of causal relations which may occur in his artificial world. He begins his investigations with the formulation of two questions: What does it mean that at some moment of time a given state p is (causally) possible? What is the modal logic of an artificially constructed world?

The Finish scholar states that these questions yield several answers. He mentions two which are particularly relevant to the problem in hand. Thus, to say that Mp is true in a given world (of a certain total state of the world) may mean that the general state described by p can be encountered in at least one of the worlds which occur 1) either directly after the given world, 2) or some time later. Both these intrepretations refer to the possibility inherent in the world which is to be transformed into another world. Von Wright stresses that both these interpretations offer different systems of modal logic. In neither of these systems can the principle ab esse ad posse be accepted. In the first logic the following thesis appears: if p holds true of the world at the next moment of time, then p is a possibility here and now. This can be expressed symbolically as follows: $tTp \rightarrow Mp$, where t represents any tautology of the logic of propositions.

Von Wright presents a number of propositions determining the sense of modal functors in the first and the second intepretations of the possibility. With the help of the formal apparatus he attempts to transcribe the proposition "p is the cause of q". He also takes into account the fact that states of affairs described by p and q may occur simultaneously. He does not introduce in the article under discussion any new specific logical constants in comparison to his earlier works. The novelty here consists in combining modal terms with specific constants of his previously constructed calculi: "And next", "And then", and "Always" [7]. These latter systems belonging to tense-logic did not contain modal terms. Modal terms and constants of tense-logic are treated in the later work as singular functors used in causal propositions. Von Wright's theses determine the meaning of these functors.

[6] G. H. von Wright. *On the Logic and Epistemology of the Causal Relation*. In: *Logic, Methodology and Philosophy of Science*. IV. Warszawa 1973 pp. 293 - 312.

[7] G. H. von Wright. *Always*. "Theoria" 34: 1968 No. 3 pp. 208 - 221.

Thus, it seems that von Wright's project of causal logic is still far too general although it does contain a number of valuable insights.

None of the authors discussing the formal problem of causal logic have offered a broader metascientific conception of the causal relation or analyzed the causal relation taking into account the problem of physics.

The problem of causality is an ontological one. It concerns certain features of reality. It cannot be solved by means of logic alone. It can only be analyzed with the help of logic. However, the problem cannot be reduced to logic. Problems of logic concern, in principle, the logical structure of propositions with the help of which we express causal judgements. An insightful study of the logics briefly discussed above reveals that they essentially refer to physical causality. The principal difficulty which arises here is connected with the adequacy of one of these logical systems to the representation of a physical causal relationship. It seems that none of them is adequate to this task. Thus, it is necessary, taking into account the achievement of these authors, to construct a system of causal logic which would reflect causality in physics. This task consists in formulating in terms of contemporary logic such everyday expressions as "if p, then q" meaning "if p, then because of it q" [8]. In the system of causal logic there arises a need to introduce a new functor which may be called the relativist implication. In determining the theoretical significance of this term it is necessary to take into account semantic considerations of the causal relation in contemporary physics. Thus, we are interested in the intuitive basis of a substantial discussion of the systems of logic that have been proposed so far in connection with their adequacy in expressing causality in physics.

The causal relation, or the relationship between cause and effect, consists in the fact that the cause brings about the effect. It is necessary to distinguish the relationship betwen objects when a two-way or one-way stream of energy flows between them and the causal relation [9]. In the most elementary cases, the causal relation consists in the unilateral transmission of energy from object A to object B. The supply of energy by object A is the cause and its acquisition by object B is the effect.

The principle of physical causality is a cognitive expression of every efficient causation. It is adopted by the naturalist before he begins his scientific investigations as a valuable directive of scientific inquiry. In formulating, and, first of all, in understanding the principle of causality it is necessary to take into account the insights taken from physical theories. The theory of relativity is at present the leading theory in physics. In terms of relativist physics it is assumed that the causal relation is identical or at least has an equal range with the relation of interaction [10]. However, there exists

[8] Cf. L. Borkowski. *Logika formalna* (*Formal logic*). Warszawa 1970 pp. 72 - 73; S. Kamiński. *Rola pewnych funktorów w logice i w języku potocznym* (*The Role of Some Functors in Logic and Everyday Speech*). "Sprawozdania Towarzystwa Naukowego KUL" 7: 1954 pp. 220 - - 221.

[9] Cf. W. Krajewski. *Związek przyczynowy* (*The Causal Relation*). Warszawa 1972 p. 181.

[10] Cf. Z. Augustynek. *Natura czasu* (*The Nature of Time*). Warszawa 1975 p. 173.

the speed limit of the transmission of energy and so there must be the speed limit of the causal relation.

Relativist physics also investigates the properties of temporal relations in connection with the investigation of electromagnetic interaction. Special theory of relativity contains an assertion that if one event acts electromagnetically upon the other it is absolutely earlier than the other [11]. Simultaneous events cannot act one upon another.

Because causal relations are identified with interaction any two events are causally related only when one of them is absolutely earlier than the other. The temporal relationship between the two events is thus absolute. If there is no causal relation between two events it may happen that what occurs earlier in relation to a given point of observation may occur later in relation to another.

Von Wright seems to ignore the differentiation (on the basis of theory of relativity) of temporal relations between events which are causally related from those relations which occur between events which are not causally related. This is demonstrated by his statement concerning the ramified character of time in relativist physics and utterances connected with it.

The character of the temporal relationship between cause and effect determined above cannot be disregarded in formulating or understanding the principle of causality in physics. In turn, the study of different formulations of this principle makes it possible to assert that the causal relation may be characterized by turning the attention to the following points: the effect is unilaterally dependent on the cause; the existence of the cause invariably involves the existence of the effect; the causal relation consists in the relation of physical interaction; effect follows cause in time. Asymmetry, irreflexitivity and transitiveness are strictly formal properties of the causal relation.

The causal relation is also assigned a necessary character. A question arises as to the sense of the statement that causal relations investigated by natural sciences have a necessary character.

The necessity of the causal relation was discussed by Łukasiewicz and other scholars. He assumed that the necessary relation between cause and effect and between reason and consequence is of the same kind. He also tried to reduce necessity to contradiction.

It seems that the necessity of the causal relation in physics is in some way assumed just like the principles of the repeatability of elements and their systems in nature are assumed. These principles cannot be proved in terms of natural sciences. The epistemological perspective of physics makes it possible only to define these assumptions more precisely. These are the assumptions that make scientific research possible. If science is to be what it is these principles must be accepted. Considering that the

[11] Cf. R. Kutz. *Wstęp do szczególnej teorii względności* (*Introduction to Special Theory of Relativity*). Warszawa 1964 pp. 34 - 36.

above assumptions constitute the framework which encompasses the principle of causality which is, in turn, a linguistic expression of the generally conceived causal relation this relation may be given the feature of necessity understood as an exceptionlessly repeating itself sequence of cause and effect in certain conditions.

Bearing in mind the above semantic considerations concerning the causal relation in contemporary physics it is easy to see that in characterizing the equivalent of the conjunction "if, then", used in some sense in physics, in the language of formal logic we must take into account more aspects of content than Burks did. The new functor necessary for this task is called the functor of relativist implication. The logic of the causal relation in physics must be a logic looking for the theses governing the application of this functor. In determining the theoretical meaning of this term theses demonstrating the relationship between the new functor and Burks' causal implications are allowed. In the new logical system there can be no lack of propositions expressing assymetry, ir reflexivity and transitiveness of the causal relation. The temporal sequence of cause and effect must be expressed and the feature of the necessity of this relation. The analysis of the necessity of the causal relation in physics briefly outlined above reveals that this feature may be expressed by means of appropriate temporal expressions. In the transcription of propositions concerning the temporal sequence and the necessity there is a need to make use of some functors, appropriately modified, of von Wright's tense-logic. It is not permissible to rely on the functors "it is possible", "it is necessary" without pointing to their sense in physics.

The above remarks concerning time in physics enable us to eliminate some possibilities. We may use von Wright's functor "And then" and not "And next" in the propositions of causal logic. And in the calculus "And then" it is possible to accept all axioms of the calculus "And next" with the exception of the second axiom which should be replaced by the axion of linearity. This axiom eliminates ramified time.

The feature of necessity has been pointed out among the features of the causal relation in physics. It is worth noting that it is von Wright who analyzes modal functors with the help of temporal expressions. Although his analyses concern the artificial world constructed by him there are no reasons against referring to events between which a causal relationship may occur instead of talking of the total states of the world.

Taking into account semantic analyses concerning the causal relation in physics it is necessary to support the second of the above mentioned interpretations of modal functors which would appear in the propositions of causal logic because the impulse of energy diffusing with a finite speed, e.g., in the form of electromagnetic radiation, may reach the bearer of effect after one, two, etc. units of time. It is not possible to distinguish any number of moments because the constructed logic would lose its generality. Thus it is not advisable to make use of the quantitative functors of the logics of temporal propositions of A. N. Prior.

The feature of asymmetry has been emphasized in the causal relation. The asymmetry of this relation is principally determined by the transmission of energy from the bearer of cause to the bearer of effect. Moreover, if a causal relation occurs between two events the change of magnitude of the dimensions of the cause results in the change of magnitude of the effect. Asymmetry of the causal relation springing from the unilateral transmission of energy may be expressed in the language of singular theory of change.

In the course of our considerations it has been demonstrated what propositions may be accepted in the system of causal logic. Although the causal relation and the cause may be treated differently by referring to everyday intuitions referring to the cause as the realiser, as a mutual interaction of elements, etc. However, for the physicist the cause is first of all the energetic cause. And the above attempt at a characterization pertains to this understanding of cause [12].

It seems that the system of causal logic constructed in the way suggested above (constructed on the basis of the sentential calculus) coincides with Łukasiewicz's conception of the relationship between logic and reality in a certain period of his thinking. However, it does not correspond (because it cannot) wholly to his conception of causality. But the very possibility of constructing the system of causal logic harmonizes with the metalogical ideas of the Polish logician. He believed that the classical logical calculus encompasses ony the most important modes of inference. Taking this into account as well as the fact that classical logic developed because of the needs of mathematics there are no reasons against constructing a linguistic and inferential apparatus useful in cotrolling causal inferences and expressions.

[12] In the course of the above summary presentation, for the sake of brevity, no attention has been paid to the causal relation occurring when the transmission of energy causes the transition of the system from the initial state to another state of a certain degree of probability.