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LOGIC AND LINGUISTICS: THE CASE OF PREDICATION

The article discusses the notion of predication, and its definitions in logic and linguistics. Definitions suggested by Carnap, Reichenbach, and Quine have implications for the understanding of predication in linguistics. The article focuses on structural approaches to predication and discusses their consequences for a linguistic theory of predication, especially within the generative approach to syntax. It is claimed that the relation between the predicate (function) and the subject (argument) is monadic and triggered by an appropriate operator.

1. Introduction

Research in philosophy of language, logic and linguistics makes ample, both explicit and implicit, use of the concept of *predication*. In traditional grammar, predication is the relation between the subject and the predicate. In logic, predication is the attributing of characteristics to a subject to produce a meaningful statement combining verbal and nominal elements. This understanding stems from Aristotelian logic, where the term (though not explicitly used by the philosopher) might be defined as "saying something about something that there is".[1] In more recent logical inquiries, this classical definition is echoed by the 'thing-property relation' (e.g. in Reichenbach 1947). Quine (1960) treats predication as the basic combination, in which general and singular terms find their contrasting roles, he also considers it to be one of the mechanisms which joins occasion sentences. This idea is close to Lorenzen's (1968) 'basic statements' (*Grundaussagen*), the simplest structures of a language which are composed of a subject and a predicate. Popper (1959) formalizes predication as one of the propositional functions (the consequent propositional function) of the general implication. Strawson (1971) stresses that predication is an assessment for truth-value of the predicate with respect to the topic, and according to Link (1998) is the basic tool for making judgments about the world.

[1] This definition may be inferred from Aristotle's concept of a proposition, understood as a "statement, with meaning as to the presence of something in a subject, or its absence, in the present, past, or future, according to the division of time" (*On Interpretation*, 17a).

In the forthcoming discussion I concentrate solely on certain structural solutions advocated by Carnap, Quine and Reichenbach, with immediate consequences for linguistic theory.[2] I entirely disregard the issue of, e.g. propositional attitudes, truth-conditions, and other topics central to research in logic but without direct significance for the structural (syntactic) approach to predication.

2. Carnap's Logical Syntax

Aristotelian logic was concerned with the relations of meaning between sentences; its semantic approach was incorporated into the traditional theory of grammar. The formal treatment of sentences, and relations between elements of a sentence, appeared with the development of formal logic and meta-logic, and especially with the rise of *Logical Positivism.* Rudolf Carnap (1891-1970) was one of the first to develop the theory of logical syntax which treated language as calculus and concentrated on the formal aspect of language. In the forward to *The Logical Syntax of Language* (1937, henceforth *LSL*), Carnap explains that he devised the theory of the logical syntax of a language in order to replace philosophy by the logic of science (i.e. by the logical analysis of the concepts and sentences of the sciences). Logical syntax is understood by Carnap as "the formal theory of the linguistic forms of that language – the systematic statement of the formal rules which govern it together with the development of the consequences which follow from these rules" (LSL, 1). The theory is formal if no reference is made to either the meaning of the symbols (e.g. the words), or to the sense of the expressions (e.g. the sentences), but solely to the kinds and order of the symbols from which the expressions are constructed (LSL, 1). The syntax of a language understood as a calculus (i.e. a system of conventions or rules) is concerned with the structures of possible serial orders of any elements whatsoever (*LSL*, 6).[3]

In Carnap's theory of symbolic language, the notion *predicate* was used in order to "express a property of an object, or of a position, or a relation between several objects or positions" (*LSL*, 13). *Descriptive predicates* express empirical properties or relations (e.g. a one-termed predicate *is blue*, a two-termed predicate *is warmer than*, etc.), whereas *logical predicates* express logico-mathematical properties or relations (e.g. *is a prime number*, *is greater than*, etc.).

In the following sentences something is predicated of something else (e.g. a property, state, or change of state is predicated of an individual):

(1) a. Jim is a boy.
b. Tom is clever.
c. Fred feels hungry.
d. Jill smiled.
e. The old lord died.

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[2] For a linguistic approach to predication, within the generative framework, see Chierchia (1985), Bowers (1993) and Stalmaszczyk (1999a). This paper develops the ideas presented in Chapter 1 of Stalmaszczyk (1999a).

[3] For a critique of such an approach to natural language, see Bar-Hillel (1970a).

Following standard accounts,[4] it is possible to formalize the above sentences by 'translating' them into the language of the first order calculus. The common *logical form* for sentences in (1) is (2):

(2) F(x)

This formula specifies the logical form of sentences in (1) by abstracting away from what the sentences are about, i.e. their content. Therefore, (2) gives information only on the syntactic construction of the sentences. In (2) 'F' stands for a predicate variable and 'x' for an individual variable. In sentences (1a–1e) 'x' is realized as an individual constant (*Jim*, *Tom*, etc.) and 'F' is realized as a respective predicate constant (*is clever*, *feels hungry*, etc.). Such sentential functions or *open* sentences are neither true nor false. In order to make a sentence out of an open sentence a certain value has to be assigned to the variable (cf. section 5, below). Another possibility of changing the open function into a sentence is through placing a quantifier followed by a variable in front of the sentential function. Quantification, however, is not discussed in this paper.

Predicate and individual constants and variables are grouped together under the name *term*, and thus another way of presenting the logical form of sentences in (1) is (3):

(3) P(t)

Formula (3) amounts to saying that a *predicate term* 'P' is followed by an *individual term* 't', and can be read as 'the predicate P is asserted of the argument *t*'. Sentences in (1) exemplify one-place predicates (i.e. functions taking one argument, monadic functions, Carnap's one-termed predicates, etc.), sentences in (4) represent two-place, three-place, and four-place predicates, respectively:

(4) a. Tom bought a dog.
b. Tom bought a dog from Jim.
c. Tom bought a dog from Jim for his sister.

The appropriate logical forms for the above sentences are given below:

(5) a. $P(t_1, t_2)$
b. $P(t_1, t_2, t_3)$
c. $P(t_1, t_2, t_3, t_4)$

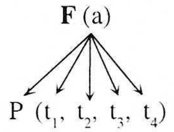
The reading for the logical form of a two-place predicate (5a) is 'the predicate P is a relation asserted to hold between two arguments t_1 and t_2'. Even very complex expressions can be regarded as predicates in logical formula, which means that the sentences in (4) may be treated as one-place predicates of the general form (6):

(6) **F**(a)

[4] Cf. for instance Strawson (1967), Kimball (1973) or Cann (1993).

In the case of example (4c), **F** stands for the predicate *bought a dog from Jim for his sister* and thus it incorporates the predicate and three individual terms (arguments) from the former logical form (5c):

(7)



The above convention might be useful in analyzing syntactic properties of predication and valency (i.e. the subcategorization requirements of lexical items), especially as form (6) reflects to some degree structural predication (in contrast to the more semantically oriented logical forms (5)). I return to this issue in section 6.

3. Quine on predication

Similar notation is used by Willard Van Orman Quine (1908-2000), who in *Word and Object* (1969, henceforth *WO*) and *Theories and Things* (1981, henceforth *TT*) distinguishes between three kinds of expressions: *predicates*, *general terms*, and *singular terms* (i.e. class names). The predicate may be regarded as a "sentence with gaps left in it where a singular term could be inserted to complete the sentence" (*TT*, 165). The general term is a sign or continuous string of signs. In grammatical terms it may be a verb or verb phrase, a noun or noun phrase, an adjective or adjective phrase, these distinctions are immaterial to logic. As observed by Quine: "If we think of a predicate as a sentence with gaps, then a general term is that special sort of predicate where the gap comes at one end" (*TT*, 164). Finally, a singular term designates a single abstract object, a class. The corresponding general term denotes any number of objects, each member of the class (*TT*, 165). Predication can be defined now as "the basic combination in which general and singular terms find their contrasting roles" (*WO*, 96). Prior to predication such words as, e.g. *dog* and *Fido* are simple occasion sentences (i.e. one word-sentences true on some occasions of utterance and false on others). Only thanks to the predication '*Fido is a dog*', '*dog*' comes to qualify as a general term denoting each dog, whereas '*Fido*' qualifies as a singular term naming one dog (*TT*, 5).

Quine differentiates between singular and plural predications and between monadic and polyadic predications, and proposes the following 'neutral logic schematism' (*WO*, 96):

(8) Monadic predication:
'**F**a', understood as
a. '*a* is an **F**' (where '**F**' represents a substantive), e.g.:
Mama is a woman.
b. '*a* is **F**' (where '**F**' represents an adjective), e.g.:
Mama is big.
c. '*a* **F**s' (where '**F**' represents an intransitive verb), e.g.:
Mama sings.

The schematism for polyadic predication, on the other hand, is given in (9) (*WO*, 105-106):

(9) Polyadic predication:
'**F***ab*', understood as
a. '*a* is **F** to *b*'
b. '*a* **F**s *b*'

Formula (9a) is the predication for relative terms, where '**F**' represents a substantive plus preposition (e.g. *brother of*), or adjective plus preposition or conjunction (e.g. *part of, bigger than, same as*). In formula (9b), '**F**' represents a transitive verb.

Quine's treatment of predication is characteristic of most logical approaches in being bipartite, i.e. it focuses on the (contrasting) roles of two elements in the relation, disregarding the importance of a possible triggering operator. Furthermore, he distinguishes between monadic and polyadic predication.

4. Reichenbach's Symbolic Logic

In one of the most influential outlines of modern logic, *Elements of Symbolic Logic* (1947, henceforth *ESL*), Hans Reichenbach (1891-1953) reintroduced the distinction, present already in classical logic and semantics, between the *sphere of objects* and the *sphere of signs*. The atomic proposition 'Aristotle was a Greek' falls into two parts: the subject, the word 'Aristotle', which refers to a man, and the predicate, the word 'Greek', which refers to a property of that man. The two parts represent the general distinction between a *thing* and a *property* (*ESL*, 80).[5] The thing and the property belong to the sphere of objects, whereas the subject and the predicate "constitute their correlates in the sphere of signs" (*ESL*, 80). This distinction is a modern counterpart of the classical differentiation between the items in the ontology and the linguistic items. Further on, things in combination with properties determine *situations* or *states of affairs*, the denotata of sentences (*ESL*, 15).

The correspondences between the two spheres may be captured in the table below:[6]

Table 1

Sphere of objects	Sphere of signs
thing	subject
property	predicate
situation / state of affairs	sentence / proposition

Furthermore, Reichenbach introduces variables into the sphere of signs. A variable is a sign which is not restricted to denoting one individual thing, or property, but which can be used to denote any thing or any property (*ESL*, 80). The general form of the sentence

[5] Cf. Chierchia (1985: 417), who by a property (or propositional function) refers to whatever Verb Phrases "are semantically associated with".

[6] For Reichenbach, propositions are the *atoms of language*, and "What makes a proposition the fundamental unit is the fact that only a whole proposition can be *true* or *false* – that, as we say, it has a *truth-value*" (*ESL*, 6). Note, however, that he does not explicitly distinguish between 'proposition', 'sentence' and 'statement', and uses these terms interchangeably (*ESL*, 5, n.2). For a discussion of the relations between 'truth', 'proposition', 'sentence' and 'meaning', see Quine (1992).

like 'Aristotle was a Greek' is symbolized now as 'f(x)'. Under this approach, the property is conceived as a function of the thing, whereas the thing is regarded as the argument of the function. The signs which denote function and argument are called function-name (or sign) and argument-name (or sign), respectively. The expression 'f(x)', including both function-name and argument-name, is called a *functional* (*ESL*, 81).

Table 2 provides the appropriate correspondences, I indicate the distinction between examples in the sphere of objects (i.e. in the ontology), and in the sphere of signs (i.e. grammar) by using inverted comas for the latter:

Table 2

Ontology (objects)	**Grammar** (signs)	**Symbolic Logic**
thing:	*subject:*	*argument-sign:*
Aristotle	'Aristotle'	x
property:	*predicate:*	*function-sign:*
Greek	'Greek'	f( )
situation:	*sentence:*	*functional:*
Aristotle is a Greek	'Aristotle is a Greek'	f(x)

The functional treatment of the thing-property relation continues the approach first developed by Frege.[7] Reichenbach is primarily interested in classifying functions and developing the calculus of functions, and therefore he limits his attention to arguments and functions. His approach to predication is essentially bipartite (though note, that the notion of predication is not used, nor explicitly analyzed, by Reichenbach). Nevertheless he observes that in the proposition 'Aristotle was a Greek', which tells us that the thing (Aristotle) has a certain property (being Greek), the phrase 'was a' "indicates that the thing-property relation holds between the objects denoted by the words 'Aristotle' and 'Greek'" (*ESL*, 80).

5. Relations, lambda-calculus and quantification over properties

Contemporary logic seldom makes explicit use of the term predication, it does, however, refer to the notion of *relation*. A relation is a state of affairs that may or may not hold between individuals.[8] Below are some examples of binary and three-place relations:

(10) a. x is less than y
b. x is a sister of y
c. x is between y and z

The notation for n-place relations in first-order logic is given below (cf. section 2), with **R** being the n-place relation symbol:

[7] For some introductory remarks on Frege and predication, see Stalmaszczyk (in press). Chierchia (1985) presents a Fregean theory of predication.

[8] Discussion and examples based on Howson (1997: 68-70). See also Kimball (1973).

(11) $\mathbf{R}(x_1, x_2, \dots x_n)$
or
$\mathbf{R}(x, y, z, \dots)$

One-place relations are called *properties* or *predicates* of individuals, e.g.:

(12) a. *x* is green
b. *x* is a prime number
c. *x* is a nuclear reactor

The relevant notation is P(x), Q (x), etc., where P and Q are the predicate symbols, whereas *x* is a placeholder for the subject of the sentence. As has already been noted in section 2, there is no assertion corresponding to the strings in (12), only when *x* is replaced by a name (closure or *saturation* of a function in Frege's terminology), or is quantified over, truth-value can be assigned. As observed by Chierchia (1985: 417), the main characteristic of properties is that they can be meaningfully attributed to (or saturated by) a subject (or argument).

Relations are somewhat differently understood in Montague Grammar and mathematical semantics. According to Aldridge (1992: 25), a relation holds between two elements in such a way as to bring them into a pair, which may or may not be ordered:

(13) a. *x* is the author of *y* (ordered relation)
b. *x* is married to *y* (unordered relation)

The relevant notation is 'yRx' understood as 'y stands in the relation, R, to x'. A relation which is uniquely valued is a *function*.[9] For instance, the relation between any number and its square, or the relation *husband of*, is a function (Aldridge 1992: 26). Functions are generalized symbolically as 'F(x)', where 'F' is the function variable and 'x' the domain variable. The value of F(x) is y. In (14a) F is the squaring function, and in (14b) F is the function *wife of*:

(14) a. F(2) = 4
b. F(Leopold Bloom) = Molly Bloom

An extension of predicate logic is the *lambda-calculus* (l-calculus), a theoretical model of computation, introduced to logic by Alonzo Church (1941) and used in formal approaches to represent semantic functions and relations. The l-calculus has been applied in formal semantics and categorial grammar (e.g. Cresswell 1973, 1985),[10] and numerous linguistic studies (e.g. Williams 1977, Dowty 1982, Ruszkiewicz 1984). The logical form (6), repeated below as (15), can be represented in a still different way, namely as a lambda-expression (l-expression) denoting certain properties (16):

[9] This is a different understanding of 'function' than in Reichenbach (1947), where the term 'function' is a synonym for 'predicate' or 'verb', e.g. *run* is a one-place function, *kill* is a two-place function, etc.
[10] See Steedman (2000) for a new approach to the theory of natural language grammar, Combinatory Categorial Grammar, and a comparison of combinatory systems and the l-calculi.

(15) **F** (a)
(16) ((lx) (F(x))) (a)

The above formula states that *a* has the property of being *F*, and can be read:

(17) *a* is an *x* such that *x* has the property *F*

The logical form of a simple intransitive sentence (18a) can be represented as a l-expression (18b) derived from the sentence's Verb Phrase (i.e. predicate) by l-interpretation with respect to the Noun Phrase, and where the lambda operator binds the variable *x*:

(18) a. John runs.
b. ((lx) (run (x))) (John)

The l-operator abstracts on the variable contained in a propositional function and binds all instances of *x* in the function. The process of replacing variables by constants and removing the l-operator is called lambda conversion: it converts a propositional function into a predicate.[11] The l-expression (18b) has the reading (18'):

(18') John is an *x* such that *x* runs.

Williams (1977) uses the lambda operator for deriving semantic interpretation (i.e. Logical Form) from the surface structure of a sentence. He introduces a rule which converts VPs present in surface structure into properties written in lambda notation: the rule affixes a lambda and a variable to a VP, and it places a variable bound by the lambda in the position of the logical subject of the verb (different from the surface grammatical subject position). This rule converts the (simplified) surface structure (19a) into the logical form (19b), where the second *x* in (19b) is in the position of the logical subject of the verb. (19b) has the reading (19'):[12]

(19) a. $[[\text{John}]_{NP}\ [\text{runs}]_{VP}]_S$
b. $[[\text{John}]_{NP}\ [\text{lx (x runs)}\ ]_{VP}]_S$

(19') John has the property of running

The lambda operator is extensively used in the framework of Montague Grammar (cf. Montague 1974, Dowty 1979, 1982), and in postulating rules of semantic interpretation for *Generalized Phrase Structure Grammar* (cf. Gazdar et al. 1985); see also Ruszkiewicz (1984) for an account of English reflexives and VP anaphora. However, as observed by Aldridge (1992: 59), the representation of (18a) as (18b) is "more complex than either the syntax or the semantics requires. We gain nothing whatever from its employment". This comment very well illustrates the general problem of applying formal notation to linguistic

[11] Cf. the discussion in Aldridge (1992: 58-61) and Cann (1993: 112-149).

[12] Cf. Williams (1977: 116). For a critical discussion, see Ruszkiewicz (1984), cf. also Dowty (1979) for a re-examination in terms of Montague Grammar.

representation. One aspect of this problem is connected with the fact that the "notation is rich enough to talk about objects of any kind and to describe any kind of relational structure over them" (Kay 1970: 117). On the other hand, the number of linguistic phenomena to be covered by such notation is quite impressive, and as remarked by Lorenzen (1968), the number of possible logical structures is minute in comparison with the richness of natural languages. As noted by Kay, the most basic translation of a very simple sentence (20) is (21), where the verb specifies properties predicated of the subject:

(20) The man ran.
(21) run (man)

Representation (21) does not account for the tense feature, relevant for establishing temporal reference. Tense may be represented by conjoining a second elementary proposition in which 'past' is predicated of 'run':[13]

(22) run (man) past (run)

Other features mentioned by Kay (1970) include gender, definitness and the primitive 'human':

(23) def (human) male (human) run (human) past (run)

Though I agree with Kay (1970: 117) that "It is by no means clear at what point the process of factoring notions into simpler notions should stop", it is worth observing that (22) captures the observation made by Aristotle in *On Interpretation* about the obligatory presence of an appropriate temporal element in a proposition (cf. note 1, above). Additionally, it opens interesting possibilities for postulating an operator for 'temporal predication' within linguistic predication.

6. From logic to linguistics

Logic representation is not a level of linguistic description.[14] However, the notations used in logic capture certain important generalizations. The same is true for definitions of predication in logic. And so, Quine's (1960: 96) definition of predication as "the basic combination in which general and singular terms find their contrasting roles", finds its counterpart in contemporary formal semantics. As explained by Link (1998: 275): "Predication relates predicates and individual terms to form sentences. Semantically, that means that some individuals are said to have properties or to stand in relations to one another".[15] Similarly Krifka

[13] Representations (22) and (23) pose serious problems for a formal account of predication since in these examples features are predicated over terms. Such an approach would require a formal typology of admissible predicates, including abstract features.

[14] Cf. the remarks in Gazdar et al. (1985: 9) on the status of intensional logic representations.

[15] Link (1998) regards predication as one of the formal metaphysical tools used to describe the structural properties that relate the various entities in the ontology. Other necessary tools include: identity, abstraction, mereology, and modality, cf. Link (1998: 273).

(1998: 209): "A predication establishes a relation of a specified type between a number of parameters, or semantic arguments". For example, sentences with intransitive verbs establish a relation that holds of the subject for some event, and sentences with transitive verbs establish a relation that holds between the subject, the object, and some event.[16]

Classification into different types of predication is in logic and formal semantics a consequence of the distinction between one-place predicates (monadic predication) and multi-place predicates, or relations (polyadic predication). I recast here this distinction for the purposes of syntactic theory (within the generative framework), and I assume that polyadic predication is a relation which occurs between a predicate and its argument(s), and is a consequence of the predicate's semantic properties. In modern generative grammar (e.g. Chomsky 1981, 1982, 1986), this type of predication is associated with semantic interpretation, and as such falls under the scope of Theta Theory, one of the modules in the Government and Binding model of generative grammar. For this reason it may be referred to as *thematic* predication. The appropriate formal context, together with a brief description is provided below:

(24) Thematic predication:
i. Argument_1 [Predicate(1,2, ...)] Argument_2 ...
ii. Thematic predication deals with semantic interpretation of argumants and thematic role assignment.

Monadic predication, on the other hand, involves a one-place predicate (though the predicate can itself be complex, with internal arguments) and a referring term functioning as its unique argument (structural subject), and can be thus termed structural predication[17]:

(25) Structural predication:
i. Subject [Predicate(1)]
ii. Structural predication deals with configurational relations between nodes described/defined on phrase markers.

In the Government and Binding model of generative grammar, the obligatory presence of the closing argument (subject) in a subject-predicate structure follows from the second clause of the Extended Projection Principle (EPP). The Projection Principle, formed in Chomsky (1981: 29), states that the subcategorization properties of each lexical item must be represented categorially at each syntactic level. Chomsky (1982: 10) extends the Principle by adding a second requirement: that clauses have subjects. Later, Chomsky (1986) suggested that this part of the EPP might be derived from the theory of predication, as developed in Williams (1980) and Rothstein (1985). Chomsky explicitly referred to Frege, and observed that a maximal projection (e.g. VP or AP) may be regarded as a syntactic function that is

[16] This is an oversimplified presentation, for a detailed analysis, see Krifka (1998).

[17] I understand monadic predication similarly to Rothstein (1992: 15), who defines it as the relation holding between the subject of a sentence and the "reminder". Cf. also Bańczerowski (1993: 17), who treats predication as a "polarization af a sentence into a subject and a predicate phrase, which exhaust this sentence completely".

"unsaturated if not provided with a subject of which it is predicated" (Chomsky 1986: 116). Most recently, Afarli and Eide (2000) propose that the EPP is the effect of a proposition-forming operation of natural language, induced by a predication operator.

There is one more crucial property of structural predication, not captured by the above descriptions. As observed already by Aristotle, predication is constituted by *three* elements: the subject, the predicate, and the tense element. According to Port Royal *Grammar* and *Logic*, all verbs include an underlying copula. Also Frege, though working in a completely different tradition, referred to the copula as the "verbal sign of predication", possibly implying to consider predication as a relation of three, rather than two, elements.[18] In accordance with these observations, I assume here that structural predication involves two terms – the subject (argument) and the predicate (function) – and additionally an *operator of predication*, which means that the schema and definition (25) are inadequate, and require the following reformulation:

(26) Structural predication:
  i. Subject [Operator [Predicate (1)]]
  ii. Structural predication deals with configurational relations between nodes described/defined on phrase markers triggered by the operator of predication.

Concluding, I have made here two basic claims about structural predication[19]:

(27) i. Structural predication is monadic, in the sense that the predicate takes only one argument (predication subject) and the relation exhausts the appropriate sentence (or clause) completely;
  ii. Structural predication is tripartite, in the sense that an appropriate operator is required to trigger predication.

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[18] See the comparison in Stalmaszczyk (1999b, and in press).

[19] For a comprehensive discussion of these claims, see Stalmaszczyk (1999a).

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