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A FORMAL SEMANTIC INTERPRETATION OF VERBS

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The aim of the present article is to offer a description of verbs that would emphasise their semantic functions within deep structures, disregard surface syntactic phenomena and refer to certain functors regarded as primary concepts. Attempts at introducing a certain set of elementary (primary) semantic concepts (semantic primitives) are currently a common trend in linguistic studies encompassing semantic analysis (Apresyan, Melchuk and others in the USSR, Katz and others in the USA, Wierzbicka in Poland). These said attempts consist in defining the elements of natural languages using simpler terms, treated as constituent concepts and combined in appropriate ways. The methods of combining them range from relatively intuitive verbal descriptions to attempts at a formal notation. Works of this kind include e.g. O. A. Wojtasiewicz's study of Polish conjunctions in sentences.

The formal apparatus employed in the present work is functional calculus (also known as predicate calculus) with elements of set theory and Boolean algebra. The constants shall, apart from the constants appearing in these formalisms, incorporate the functors mentioned in the first paragraph, regarded as primary concepts of the system and equivalent to certain elementary semantic notions. Each functor will be introduced in a meta-systemic manner by determining its semantic interpretation and the number of its arguments. The syntactic category of each argument will also be identified; only two categories are accepted, namely a proper name and a sentence. It is also assumed that in the case of functors that take more than one argument the order of the said arguments is fixed and has a syntactic function (and,

indirectly, also a semantic one, as the position of a given argument is related to its semantic role stemming from the interpretation of the functor).

Furthermore, it is assumed that each functor along with its specific arguments (i.e. the correct number of arguments, each of which belongs to the syntactic category appropriate for a given case) has the syntactic category of a sentence and therefore (in a more complex expression) may become an argument of a functor of one type or another in cases where the rules of syntax stipulate the use of an argument having the syntactic category of a sentence. In the introductory meta-systemic description the arguments will be represented with initial letters of the Latin alphabet; in the analysis of verbs they will be represented by the final letters of the alphabet.

Some functors will, out of necessity, have the nature of variables, not constants. This choice stems from the need to identify certain semantic facts in the analysis without developing an overly large (at least for the current phase of the analysis) repertoire of semantic constants. Various formal operations will be used, however, to reduce the number of variable functors as far as possible.

Another aspect that needs to be taken into account in a description of the meaning of verbs is time. What is meant here is not the category of grammatical tense included in many natural languages, but the temporal relations arising from the meaning of the verb itself. To forestall future interpretations, an example might be in order: the verb *dziwić się* ('to wonder') indicates that a person has at a certain moment learnt about some occurrence (or fact) that they had at some EARLIER moment considered at least unlikely. The relation of previousness is embedded in the very meaning of the verb; it may be treated as a relative chronology, independent of the grammatical tense in which the verb is being used. The technicalities related to this understanding of temporal relations are provided in a further section of the article.

The author of the present study wished to present a semantic description of verbs that would be as dependent on the grammatical properties of the analysed verbs as possible. Such a description could then be used to construct a so-called intermediary language for machine translation, i.e. a form of an artificial language that retains the meaning but is independent of the grammatical structure of both the source and the target language.

The present study focuses on examples from the Polish language, in some cases comparing them with English verbs or words in other languages. The analysis of the Polish example verbs introduces certain methods that

make it possible to specify that some purely surface elements will not be taken into consideration; on the other hand these methods may, if need be, indicate whether in the given case the variable included in the example is understood as a sentence or as a proper name (this allows the surface structures to be taken into account to some degree, yet appears necessary; it makes it possible to choose such an interpretation for a different language that will be appropriate even if the surface structure of the language differs in a given aspect from the surface structure of the Polish language; it must be remembered that the analysis must start from examples in a specific language, which forces the scholar to deviate from the initial theoretical premise of disregarding surface structures). If the need arises, the analysis will include pragmatic elements incorporated in the verbs under consideration; as the meaning of some verbs hint at the attitude of the speaker towards the content of the utterance.

As it turns out, the meaning of at least some verbs is connected to the meaning of other elements in the sentence (if the verb is regarded as defining a certain relation, what is meant is the meaning of at least some elements of this relation). For this reason, the present study cannot be regarded as an analysis of verbs as purely lexical components interpreted out of context. Due to the fact that the meaning of verbs depends on the context the analysis needs to be extended to include certain other elements of the sentence in which the verb appears. Thus, the present article contains semantic analysis of certain utterances understood intuitively as minimal sentences, i.e. containing only the components necessary for the purpose of analysing a given phenomenon. A proper definition of a minimal sentence is very complicated and shall not be discussed.

In symbolic notation the temporal aspect will be represented in the form of subscripts to the right of the symbol of the sentence (when the symbol is singular) or to the right of the functor (when the sentence is represented by more than one symbol); if other subscripts appear (which is possible, especially if the notation of the given sentence includes a functor), they will be separated with commas.

In the formula the model of the sentence under analysis will be presented on the left side, whereas the right side shall contain its equivalent in a detailed symbolic notation. The colon dividing the two parts ought to be interpreted as the symbol of definitional equivalence.

To avoid overly complex symbolic notation to the right side of the formula, in some cases a previously described verb included in the symbolic interpretation shall be repeated in English; in a full notation it would have

to be replaced with its previously presented notational form. The symbols of functors and certain other terms are also given in English or in a form referring to certain words in the English language.

The following section contains a description of the terminological apparatus and the forms of symbolic notation that shall be used throughout the present analysis.

(1) $L(a,b)$,

where L represents the relation of spatial location, a is a proper name or a sentence and defines the item or occurrence which is being localised, and b is the name defining the localising item (the localiser). This relation is transitive (all relations analysed in the present work are treated as non-reflexive and asymmetrical — the latter property results from associating the positions of arguments with semantic roles; a given relation is transitive only if it is explicitly stated in its description).

(2) $T(a,b)$,

where T represents the relation of temporal localisation, a is a proper name or a sentence and defines an occurrence which is being localised, and b is a name or a sentence defining the localising occurrence (the understanding of the term 'occurrence' incorporates also complex and long-lasting processes that are not referred to as occurrences in colloquial language). The relation is transitive.

To add to the complexity of the problem, in many natural languages occurrences which ought to be described with sentences are expressed as proper names, such as *wypadek* (an accident), *pożar* (a fire), *wojna* (a war). The same is true in relation to conventional chronological terms: *Jan Sobieski żył w wieku siedemnastym* (Jan Sobieski lived in the seventeenth century) has the meaning of *Jan Sobieski żył wtedy, kiedy był wiek siedemnasty* (Jan Sobieski lived when it was seventeenth century). Many languages include elements which have, within the framework of reism, been labelled 'apparent names'; this linguistic custom shall be taken into account in the present analysis. It could be argued that a denotation of an occurrence is always a sentence from a semantic point of view, yet in terms of syntax it is not always so — the discrepancies are observable even within a single language, let alone between various languages.

(3) $Ex(a)$,

where Ex is a predicate signifying material existence, a is a proper name denoting a material object (or a complex one colloquially not referred to as an object). The predicate Ex should not be regarded as signifying continuing life in the cases where a denotes a living organism; thus, the transition

from existence to non-existence (the relations of transition from one state to another shall be discussed below) ought not to be interpreted as the death of a living being. This reservation may be insignificant in many cases, yet for some may prove crucial: for example from the point of view of forensic medicine a corpse is an existing material object which would only cease to exist e.g. if burned, etc.

It must be emphasised that the functor *Ex* cannot be identified with a quantifier of existence. The functor clearly determines the ontological status of its argument as material (or intentionally material) existence, whereas a quantifier of existence indicates only that a certain object may be identified in some way, without defining the ontological status of the said object. For example, if we say that there exists such an x that x is an even primary number, we are only stating that we are able to identify an object that would comply with certain requirements. We are not in any way commenting on the ontological status of natural numbers.

(4) $Trans(a,b)$,

where *Trans* represents a relation signifying the transition from one state to another, a and b are sentences denoting the two states (even if in colloquial speech a given state is described by a proper name, semantically speaking the denotation of a state needs to be expressed by a sentence). The relation is transitive.

(5) $Trans(a,b) \rightarrow \bigvee_{t,t'}, \quad Trans(a_t,b_{t'}) \wedge (t < t')$,

where t, t' are (relative) denotations of time, the less-than sign appearing between the denotations of time should be interpreted as the relation of previousness. As regards the arguments of the functor *Trans*, the state represented by a always precedes the state represented by b, therefore the subscripts indicating the relative denotations of time will be disregarded in the case of $Trans(a,b)$ as providing no new information. Due to the transitive nature of the relation of previousness, the inclusion of the denotations of time is not at variance with the transitiveness of the relation of *Trans*.

(6) $Ag(a,b)$,

where *Ag* represents the relation between the agent and the result of its actions, a is the proper name denoting the agent, and b is the sentence describing the result of the action. The agent is invariably understood as a material object (if it is an intentional object, it is understood as intentionally material).

Theoretically, this notation could take the form of a relation of causality, represented e.g. as $Caus(a,b)$ with arguments belonging to the

same syntactic categories as the arguments of *Ag*. The decision for introducing the *Ag* symbol was dictated by the wish to be free (at least with regard to wording and associations) of the notion of causality and source. The notions are firmly embedded in philosophy and its tradition often bordering on the metaphysical.

It must also be noted that the relation of *Ag* is interpreted purely in terms of result, not intention, i.e. in the sense that "*a* acts SO THAT *b*" and not "*a* acts SO AS TO *b*." In simpler terms, in the official interpretation the agent does not have to be a human being. It may very well be a mechanical device or a manifestation of the forces of nature, e.g. the wind or an avalanche, i.e. objects that are not associated with the intention to produce a given result.

The present analysis will also employ the following formulas:

(7) $Ag(a,b) \rightarrow \bigvee_{t}, t' \, Ag(a_t,b_{t'}) \wedge (t \leqslant t')$.

(8) $B(a,b)$,

where B represents the relation existing between an entity nurturing a certain belief and the said belief; a is a proper name (of the entity who holds the belief), whereas b is a sentence (describing the belief). The selection limitations for a are as follows: human beings (individuals or groups) and objects intentionally regarded as anthropomorphic. Specifying any selection limitations for b does not seem possible, because — as may be surmised — anything may become the subject of a belief.

The relation B shall be governed by the following (axiomatic) principle:

(9) $B_t(a, \neg\, b) \rightarrow \neg\, B_t(\mathrm{a,b})$,

which is indubitably in accordance with all intuition. It must, however, be added that the opposite implication does NOT occur. The axiom is made in the spirit of intuitionism (as an approach to the study of the foundations of mathematics) at least in the sense that it postulates that a negative statement cannot be the foundation of a positive conclusion. This assumption is in accord with our experience, at least with regard to the relation under consideration: if somebody is convinced that an even primary number does not exist, then this person is not convinced that an even primary number exists (this is an example of using formula (9) in practice); however, if somebody is not convinced that an even primary number exists, it does NOT implicate that this person is convinced that an even primary number does not exist — the person may simply not know the term 'primary number' etc. Including an implication opposite to (9) would therefore be an error.

(10) $S(a,b)$,

where S signifies the relation between the sender of an information and the piece of information conveyed; a is the proper name denoting the sender, while b is a sentence describing the piece of information. The sender of the information is understood very broadly: the notion incorporates senders that may be associated with the wish to convey information (i.e. human beings and objects intentionally interpreted as anthropomorphic) as well as instruments of conveying information (mathematical devices, thermometers, thermographs, barometers, barographs, manometers, etc.) to which such an intention is not ascribed. The differentiation between a human sender and a device may — if needed — be introduced by referring to the relation B connected to holding a belief. As it has been mentioned above, the ability to hold beliefs is ascribed only to humans (or anthropomorphic beings — this emendation is general in character and shall not be mentioned further in the course of the present analysis). The notion of the sender does not include such sources of information as indexical signs (to use Peirce's terminology) emerging in a purely natural fashion without the participation of man-made information devices. Thus, growth rings on a tree trunk which may — to certain people and in certain circumstances — be a source of information regarding the life of a given tree, shall not be included in the category of senders of information employed in the present article.

The relation S shall be governed by the following (axiomatic) principle, analogous to (9):

(11) $S_t(a, \neg\, b) \rightarrow\ \neg\, S_t$(a,b).

The opposite implication does not occur, which seems even more apparent than in the case of the relation B: if somebody is informing that not-b, they are also not informing that b; however, the fact that somebody is not informing that b cannot imply that they are informing that not-b, since the sender may simply not be conveying any information at the time.

The relation S shall additionally be governed by another axiomatic principle, which is slightly more complex and, for the sake of clarity, includes the subscripts signifying temporal relations:

(12) $S_t(a, \neg\, b) \rightarrow \bigvee_c Ex_t(c) \wedge R^3_1(c,b)$.

The above formula is an explication of the notion of the relation S rather than its definition: the right side of the equation does not feature the symbol S, yet — as will soon become apparent — the interpretation of the relation R^3_1 refers to the concept of information. Thus, from a semantic point of view there is no new input. The formula (12) should be interpreted as follows: if someone sends a piece of information, then at the same time there exists a

certain object which is the material carrier of this piece of information. The relation on the right side of the equation shall be explained in detailed in a later section; the entire formula is presented mainly for interpretational purposes. The necessity (or lack thereof) to include the formula in the system of the analysed formalised notation of the meaning of verbs is hard to assess, at least at the present stage.

(13) $Exp(a,b)$,

where *Exp* signifies the relation between the entity experiencing a sensation and the sensation itself; a represents the experiencing entity, whereas b is a sentence describing the sensation. The term 'experiencing entity' is also used in a relatively broad understanding: it may also be an instrument capable of receiving information (and therefore also of reacting to new data), i.e. an object which cannot be described as conscious. The method for specifying that the entity is a conscious being shall be discussed in a later section of the present analysis. Imposing more restrictive selection requirements on a when necessary will make it possible to create varying interpretations of the relation *Exp*. It should also be remembered that received information may also appear within the experiencing entity and pertain e.g. to its internal condition. The relation S refers to (sending) sign-based information; *Exp*, in turn, may also pertain to (receiving) information in the so-called sensation codes (the term was introduced by Henryk Greniewski).

The relation *Exp* shall be governed by the analogous axiomatic principle:

(14) $Exp_t(\ a, \neg\ b) \rightarrow\ \neg\ Exp_t(a,b)$.

(15) $M\ (a,b,c)$,

where M is the (tripartite) relation of ascribing a given measure to something by someone or something; a is the proper name of the measuring entity (a human being or a device), b signifies the proper name of the subject of measuring and c is the name of the measure ascribed to subject b by a as a result of measuring.

(16) $V\ (a,b,c)$,

where V is the (tripartite) relation of ascribing a given value to something by someone; a signifies the proper name of the human being (individual or group) that ascribes the value, b is a sentence describing the evaluated occurrence, while c is the name of the value being ascribed to occurrence b by a.

Despite the considerable similarity between the relations M and V, these two differ in some significant aspects; the difference consists not only in the semantic interpretation of the designates of the name c (in the first

case it is a numerical measure, including the so-called fundamental units; in the latter case it is a quasi-measure which cannot be expressed in numbers), but also in purely syntactic considerations: in the case of M, b is a name-type argument, whereas in the case of V b is a sentence-type argument. This is because we are able to ascribe value only to states, situations or, generally speaking, occurrences, i.e. phenomena that may only be described using sentences.

Another method of comparing measures is the less-than sign ($<$). It may also be applied to comparing values, provided that values are portrayed on a scale with a conventional zero point, so that for all values c, if $c > 0$, the value ascribed is positive; and if $c < 0$, the value is negative. Zero points — on appropriate scales — may also be adapted in the case of measures, yet it appears that in practice it would be redundant for the present analysis.

(17) $Prob(a, [i,j])$,

where *Prob* represents the relation between a certain occurrence and the subjective probability ascribed to it, a is the proper name denoting the occurrence and $[i,j]$ is a closed interval constituting the measure of probability ascribed to the occurrence designated by a. Furthermore, i, j needs to comply with the (obvious) conditions:

(18) $(0 \leqslant i \leqslant j \leqslant 1)$.

In cases when $i = j$ the probability is defined by a single point; such instances do not seem to have any significant role in the present analysis. It is much more important to note that assuming prerequisites such as: $j = 0$, $j > 0$, $i = 1$ allows us to define respectively: impossibility, possibility and inevitability. This, in turn, enables us to describe certain modal verbs and such hypothetical cases in which the meaning of the verb implies modal concepts.

In most cases the probability will be subjective — because verbs referring to some notion of probability usually imply subjectivity. For this reason, the notation equivalent to formula (17) shall appear as the second argument of the functor B or as an element of the second argument of the said functor. Thus, the analysis shall contain formulas such as $B(..., Prob(a, [i,j]), ...)$, where the first '...' symbol will be substituted with the (obligatory) argument of the functor B denoting the subject of a given belief, while the second '...' will be substituted with the (optional) second element of the argument detailing the content of the belief.

The following section shall present the part of the apparatus that may in many cases be considered the least specific and might result in the solutions proposed in the analysis being called ineffective. The allegation,

at least to a certain degree, pertains mostly to our manner of speaking; in cases when it applies to the stipulations of the analysis it must be noted that limiting the range of extra-logical concepts introduced to the present work was a necessity: if the repertoire of such concepts would be extended to a greater degree, all the non-definiteness characteristic for natural languages which formal notation tries to eliminate (as much as it is possible) would be reintroduced, so to speak, through the back door, under the guise of an overly large set of extra-logical concepts assumed to be primary and therefore remaining undefined. As far as possible, the present article shall introduce formal measures intended to make the proposed solutions less ineffective. Perhaps further study may result in limiting the number of ineffective suggestions to the minimum; but that will probably be feasible only much later.

Let us introduce the concept of a single-argument functor playing the role of a predicate and represented generally as:

(19) $P_i(a)$,

where a signifies the proper name of a material object, while i is a certain indicator defining the place of the predicate in a given case and in the hypothetical future list of such predicates. For the time being, in individual cases i shall be introduced into the *definiens* as a variable bound to the quantifier of existence; the binding is necessary, since the variable i shall not appear in the *definiendum*. If a given notation will contain more than one predicate, they will be supplemented with varying subscripts; owing to this general assumption it will not be necessary to supplement each individual case with the provision that $i \neq j$, etc.

Where possible, the subscript i may be substituted with a variable that is free in the *definiendum* and, as such, does not require to be bound to a quantifier. The details shall become clearer as we move on to discussing specific examples.

The formula (19) should be interpreted as: "a is in the state of P_i;" as in the case of the functor *Ag*, the interpretation is something of a verbal trick: the predicates define characteristics, but it is our intention to (a) avoid using the term 'characteristic' and the philosophical connotations it evokes and (b) to adjust the terminology to the discourse used in automata theory, system theory etc. These frameworks often mention the state of certain systems and the transition of a system from one state to another. Incidentally, the latter phrase is directly related to the interpretation of the functor *Trans*.

Another concept that needs to be introduced is the marked predicate P_0 interpreted as a constant; represented as:

(20) $\mathrm{P}_0(a)$

which ought to be interpreted as: "a is in a state atypical for itself." This statement requires some further explanation. The interpretation assumed for this formula is intuitive, meaning that e.g. a given person is in a state typical for themselves if they are healthy and do not exhibit any anatomical anomaly. Naturally, it might be argued that the boundary between the norm and pathological anomaly is difficult to ascertain; the boundary between health and illness even more so. It seems, however, that the risk of error is smaller than one would expect, especially since the formula is designed to interpret the meaning of certain verbs implying the notion of a typical state, and not for solving problems e.g. of a medical nature. By saying *Kowalski choruje* (Kowalski is ill) we are expressing the view that he is not well, and thus — in accordance with the terminology presented above — he is not in his typical state. The fact whether Kowalski's state would be called an illness from a medical point of view is irrelevant for the interpretation of the above sentence. In the case of mechanical devices etc. the standard state is one in which they are able to function as intended.

Let us also introduce bipartite and tripartite relations of the R_n^m type, each supplemented with subscripts and superscripts. In practice, the superscript will always contain a natural number, specifying the syntactic type of relation (i.e. the number of arguments and their semantic categories). As in the case of predicates, the subscript may contain a bound variable or a variable which appears in the *definiendum* as free. If a given formula includes more than one relation with a subscript bound to a quantifier, it shall be assumed that the different subscripts signify different relations. For the time being, four syntactic types of relations need to be introduced:

(21) $R_i^1(a,\ b)$,

where a and b are proper names;

(22) $R_i^2(a,\ b,\ c)$,

where a, b, c are proper names;

(23) $R_i^3(a,\ b)$,

where a is a proper name and b is a sentence;

(24) $R_i^4(a,\ b)$,

where a and b are predicates.

The formula (24) requires additional explanation. From a syntactic point of view, the role of arguments of the functors have been taken, thus far, only by proper names and sentences. A predicate functioning as an argument needs to be introduced explicitly; this solution is well known from categorial grammar, where 'proper name' and 'sentence' are treated as basic

concepts, whereas other syntactic categories are defined with the use of these two concepts. Our predicates have the syntactic category of s/n and after a proper name (n) is added on the right side, they become sentences (s).

What is more, in order to limit the ineffectiveness of the formulas, certain relations shall be introduced as constant; their interpretations may be somewhat general, yet referring to them appears advisable:

(25) $R^1_1(a,\ b)$.

The formula represents the relation of possession (a possesses b; where the term 'possession' is understood very broadly and includes ownership, possession *sensu stricto*, governing, etc., and is always interpreted as a legal relationship);

(26) $R^1_2(a,\ b)$.

The formula represents the relation of a physical or sensory contact of a with b;

(27) $R^1_3(a,\ b)$.

The formula represents the relation of a purely mental (notional) contact that a has with b;

(28) $R^1_4(a,\ b)$.

The formula represents the relation of a social (or, broadly speaking, legal) contact of a and b;

(29) $R^1_5(a,\ b)$.

The formula represents the relation of domination of a over b in a certain aspect;

(30) $R^1_6(a,\ b)$.

The formula represents the relation of equivalence (similarity) of a and b in a certain aspect;

(31) $R^1_7(a,\ b)$.

The formula represents the relation of a having b in his/her/its memory, where a may be a human being, an animal or an electronic device equipped with a memory;

(32) $R^2_1(a,\ b,\ c)$.

The formula represents the relation of a using b upon c, where b is a tool or an auxiliary substance (further explanation shall be provided during the analysis of specific examples).

(33) $R^2_2(a,\ b,\ c)$.

The formula represents the relation of a lying between b and c (purely geometrically or in a given scale);

(34) $R^3_1(a,\ b)$.

The formula represents the relation between the carrier of information a and the content of the piece of data b.

As mentioned in the introduction, in the analysed examples the variables appearing as the arguments of the verb (regarded as a functor) shall be represented with the final letters of the alphabet, namely x, y, z, u, v, w; the letter t (with optional apostrophes) is reserved for indicating temporal relations. In particular cases certain variables from the x to w series will have to be introduced into the *definiens* as bound; it will be so in the instances when the meaning of the *definiendum* suggests that the implication pertains to an implicit element not expressed in the surface structure, yet crucial for explaining the meaning of the *definiendum* (typical examples include sentences in the passive voice that do not mention the agent, e.g. *list został wysłany w piątek* — the letter was sent on Friday — which implies that somebody sent the letter; the role of this person, though not mentioned explicitly, needs to be specified in the *definiens* that constitutes the semantic interpretation of the sentence).

Furthermore, in cases when the sentence implies a certain view of the speaker or a situation they are in, in the *definiens* the speaker shall be represented by the symbol s regarded as a constant and, as such, not bound by any quantifier; it could also be assumed that this is a variable introduced to the *definiens* for the purpose of semantic interpretation, in which case s ought to be bound to a quantifier — yet this is a matter of convention; the present article adapts the convention of s as a constant, as it reduces the number of bound variables.

In order to interpret certain cases of the application of the model xV_ky (where x is a proper name, V_k represents a verb and y represents a sentence; details shall be provided for particular examples), it has to be noted that the sentence y is semantically bound to x as its element (e.g. x may be the subject of sentence y, not expressed in the surface structure); in such cases the *definiens* should include the notation: $y = y(x)$, which specifies that sentence y refers to x in a certain way.

Individual variables will often require categorisation, i.e. their selection requirements will have to be specified. This may also pertain to variables that appear (as bound) only in the *definiens*. Such categorisation will be represented in accordance with set theory; the names of the sets shall be introduced gradually as the need arises and explicated as soon as they appear. The understanding of these concepts is based on rather colloquial meanings; the risk of ambiguity and vagueness is reduced due to the fact that the interpretation of these concepts is only indirectly dependent on

understanding the meaning of the individual verbs; as before, the aim was to reduce the names of sets of arguments and the sets whose elements may include variables appearing only in the *definiens*.

A more detailed and specific categorisation shall be developed later, for a future version of the present analysis. A preliminary investigation of this issue suggests that certain problems may arise with regard to the specialised meaning of certain verbs (e.g. *kopać* in the meaning of 'striking something with one's leg'), which may require the inclusion of certain categories of arguments with a very broad scope. On the other hand, it must be remembered that even at the present stage of study certain general categorisations of at least some of the arguments stem from the characteristic of such arguments as *Ag*, *B*, *S*, etc., specified when they were first introduced. Moreover, in some cases the meaning of verbs is extended — sometimes the set of their arguments (this often happens to the argument which, in the surface structure of the Polish language, acts as the subject) starts to include objects that did not use to assume this role. This phenomenon can be observed e.g. in the case of information tools (e.g. *Zegar wskazuje godzinę X* — the clock indicates hour X); the set of such instruments is rapidly expanding. In the last few decades calculating machines have started to be mentioned as the agents of actions previously associated only with human beings.

Additionally, we need to introduce the concept of the relation of being a part of something, i.e. Boolean or mereological relation, represented with $\subset^{o}$.

The examples analysed in the present study are mostly sentences in the present tense, in third person singular. The grammatical person was chosen due to the fact that such sentences tend to be semantically unmarked; sentences in first and second person cause additional difficulties that shall perhaps be discussed later. The choice of the present tense was dictated by similar reasons: in many cases sentences in the future tense touch on the issue of their logical value (which may be unspecified); in some cases it will be necessary to present examples in the past tense — namely in the instances when the meaning of the verb entails describing an occurrence that had already taken place.

One further reservation must also be made with regard to the indication of temporal relations represented in the form of subscripts; in the present version of the analysis the proviso is formulated in a rather intuitive manner. If a complex formal notation contains elements with subscripts indicating temporal relations, and we want to substitute (at least) one of

these elements with a previously introduced formula which includes its own subscripts related to temporality, the subscripts in the added formula need to be adjusted, so that they differ from the ones appearing in the remaining parts of the notation.

The analysis shall proceed in the following order: first we will present selected uses of the verbs *być* (to be) and *mieć* (to have; the two verbs appear very frequently in the surface structures of many natural languages, as well as in clearly idiomatic structures; the specificity of the uses of these verbs in various languages is evidenced in the series of books issued by Mouton); the analysis will be limited to certain basic uses typical for Indo-European languages. Later we shall discuss verbs whose semantic interpretation contains references to the predicate P_0. Further on we will analyse verbs that — from the perspective of the methods of interpretation adapted in the present study — may be divided into certain groups. Lastly, verbs treated individually or categorised into relatively small groups shall be analysed.

(35) x JEST $y : P_y(x)$.
[x IS $y : P_y(x)$.]

Interpretation: x is in the state defined by y. This represents a copulative use of the verb 'to be' typical for many languages (or at least many Indo-European ones), in which y is a noun (or is semantically interpreted as a noun).

(36) x JEST y-*owy* : $P_y(x)$.
[x IS y-*ish* : $P_y(x)$.]

The interpretation is analogous to (35), but here y is interpreted as an adjective. The difference between (35) and (36) is apparent only in the surface structure, since in both cases the sentence states that x is an element of a certain set. To keep the interpretation uniform, the concept of belonging to a set shall be represented by identifying the predicate that defines this affinity, and not by set membership (i.e. $x \in y$).

(37) x JEST y-*em* z-*a* : $R^1_y(z, x)$.
[x IS y of $z : R^1_y(z, x)$].

Interpretation: a relation (of a given syntactic type) determined by y exists between x and z. For example, the sentence *Warszawa jest stolicą Polski* (Warsaw is the capital of Poland) would be presented as: $R^1{}_{stolica}(Warszawa, Polska)$ $[R^1{}_{capital}(Warsaw, Poland)]$.

(38) x JEST y-*em* W $z : P_y(x) \wedge L(x, z)$.
[x IS y in $z : P_y(x) \wedge L(x, z)$].

Interpretation: x is in a state determined by y and x is located with regard

to z. E.g. *Warszawa jest miastem w Polsce* [Warsaw is a city in Poland]: $P_{miasto}(Warszawa) \wedge L(Warszawa, Polska)$ $[P_{city}(Warsaw) \wedge L(Warsaw, Poland)]$.

Some difficulties, or at least complications, arise in cases such as *Warszawa jest największym miastem w Polsce* (Warsaw is the largest city in Poland) or *Maria jest drugą żoną Kowalskiego* (Maria is Kowalski's second wife). It must, however, be noted that these obstacles arise in connection not with the verb itself, but with the description of certain elements in the sentence that are not verbs. The first example is relatively easy to interpret, due to the mathematical nature of the relation: Warsaw is a city in Poland and for all u that is a city in Poland, Warsaw is greater than or equal to u. The formal notation for this example would be as follows:

(39) $P_y(x) \wedge L(x, z) \wedge \bigvee\limits_{v,w} \bigwedge\limits_{u}(P_y(u) \wedge L(u, z)) \rightarrow (M(s, x, v) \wedge M(s, u, w) \wedge (v \geqslant w))$.

This interpretation may seem complicated, but is merely the formal notation of the verbal formula presented above: the state of x is determined by y, x is located in z and there exist certain v and w that for every u that complies with the same requirements as x, the speaker associates x with a measure equal or greater than that ascribed to u.

The second example poses more difficulty, as it requires referring to more complex situations: Maria is currently Kowalski's wife, and in the past there existed exactly one object other than Maria that was Kowalski's wife. The suggested formula:

(40) $\bigvee\limits_{t}, t' \bigvee^1 u\ R^1_{y,t}(x, z) \wedge (u \neq x) \wedge R^1_{y,t'}(u, z) \wedge (t' < t)$,

where $\bigvee^1$ is a definitional abbreviation standing for "there exists exactly one such item that." As noted above, the complications in symbolic notation are not directly related to the description of the verb *być* (to be).

(41) x MA $y : R^1_1(x, y)$.
$[x$ HAS $y : R^1_1(x, y)]$.

where *mieć* (to be) is used in the loosely legal sense of possession and $R^1_1$is the constant discussed above (cf. (25)).

(42) x MA *y-owe* $z : (z \subset^{o} x) \wedge P_y(z)$.
$[x$ HAS *y-ish* $z : (z \subset^{o} x) \wedge P_y(z)]$.

The formula pertains to cases of the so-called inalienable possession, i.e. utterances pertaining most typically to the features of a person's body; describing such features is semantically necessary, since stating simply that *Zosia ma oczy* (Zosia has eyes) introduces no new information; as opposed to the sentence *Zosia ma niebieskie oczy* (Zosia has blue eyes). If this statement

is evaluative in nature, its interpretation is different:

(43) x MA *y-owe* $z : (z \subset^{o} x) \wedge V(s, z, y)$.
$[x$ HAS *y-ish* $z : (z \subset^{o} x) \wedge V(s, z, y)]$.

In Indo-European languages the verb 'to have' is relatively often used in sentences of the following type: *Kowalski ma zapalenie płuc* [Kowalski has pneumonia]. In such cases it should be interpreted as:

(44) x MA $y : P_y(x) \wedge (y \in Dis)$,
$[x$ HAS $y : P_y(x) \wedge (y \in Dis)]$,
where *Dis* represents the set of medical conditions.

In this case it is also possible to use the notion of a typical state and formulate an interpretation that differs in terms of notation, but is semantically equivalent:

(45) x MA $y : P_y(x) \wedge \bigwedge\limits_{z}(P_y(z) \rightarrow \neg P_0(z))$.
$[x$ HAS $y : P_y(x) \wedge \bigwedge\limits_{z}(P_y(z) \rightarrow \neg P_0(z))]$.

Interpretation: x is in a state determined by y and all that are in such a state are in an atypical state. The above notation employs the typical state marked with P_0. More examples of using this concept will be presented in the interpretation of other verbs.

(46) x JEST ZDROWY : $P_0(x) \wedge (x \in Anim)$.
$[x$ IS HEALTHY : $P_0(x) \wedge (x \in Anim)]$.

Interpretation: x is in a state typical for x and x belongs to the set of living creatures.

The concept of P_0 proves particularly useful for interpreting expressions such as *człowiek ma dwie nogi* (A human has two legs), *pająki mają po osiem nóg* (spiders have eight legs) etc., where *człowiek*, *pająki* (or the singular form *pająk*, with the necessary changes in the sentence) signify a species or a category. It appears that interpretation based on quantifiers proves inaccurate for such cases: the use a general quantifier ("for every x, if x is a human, then x has two legs") results in false sentences, whereas the quantifier of existence ("for a certain x, if x is a human being, then x has two legs") produces sentences that are veritable, but intuitively perceived as distinctly inadequate. By referring to the concept of the state P_0 we are able to formulate an interpretation that is consistent with our intuition:

(47) x MA k *y-ów* : $P_0(x) \rightarrow ((y \subset^{o} x) \wedge M(s, y, k))$.
$[x$ has k *ys* : $P_0(x) \rightarrow ((y \subset^{o} x) \wedge M(s, y, k))]$.

(48) y CHORUJE : $\neg P_0(x) \wedge (x \in Anim)$.
$[y$ IS ILL : $\neg P_0(x) \wedge (x \in Anim)]$.

(49) x ZDROWIEJE : $Trans(\neg P_0(x), P_0(x)) \wedge (x \in Anim)$.

[x IS RECOVERING : $Trans(\neg\ P_0(x),\ P_0(x)) \wedge (x \in\ Anim)$].

(50) x ZACHOROWAŁ : $Trans(P_0(x),\ \neg\ P_0(x)) \wedge (x \in\ Anim)$.

[x WAS TAKEN ILL : $Trans(P_0(x),\ \neg\ P_0(x)) \wedge (x \in Anim)$.]

The formula (50) refers to a verb in the past tense, as the present-tense form *zachorowuje* (analogous to *zdrowieje*) is not in use. This does not seem to be a peculiarity observable only in the Polish language: the English equivalent 'is being taken ill' does not seem correct either. It may therefore be surmised that the core of the issue lies in semantics: we do say that someone 'is recovering' (*powraca do zdrowia*), but use the perfective form when reporting that somebody 'has fallen ill' (*zapadł na zdrowiu*) — except in cases when e.g. 'Kowalski often falls ill (*Kowalski często zapada na zdrowiu*).

(51) x CIERPI : $\bigvee_y Exp(x,\ \neg\ P_0(x)) \wedge\ V(x,\ \neg\ P_0(x),\ y) \wedge (y < 0)$.

[x SUFFERS : $\bigvee_y Exp(x,\ \neg\ P_0(x)) \wedge\ V(x,\ \neg\ P_0(x),\ y) \wedge (y < 0)$.]

Interpretation: x is experiencing that x is in a non-standard state and ascribes a negative value to this state. The use of the functor *Exp* implies that x belongs to a category of objects associated with the ability to experience.

(52) x PSUJE SIĘ: $Trans(P_0(x),\ \neg\ P_0(x))$,

[x BREAKS DOWN: $Trans(P_0(x),\ \neg\ P_0(x))$,]

This interpretation could also pertain to verbs such as *niszczeć* (to decay), *gnić* (to rot), *butwieć* (to moulder); in the latter two cases it might be necessary to add a selection limitation: $x \in\ Org$ (x is an organic substance).

(53) x PSUJE y : $Ag(x,\ Trans\ (P_0(y),\ \neg\ P_0(y))$.

[x DAMAGES y : $Ag(x,\ Trans\ (P_0(y),\ \neg\ P_0(y))$].

Interpretation: x acts so that y goes from a typical to an atypical state. The same formula may be used for the verb *uszkadzać* (to impair).

(54) x naprawia y : $Ag(x,\ Trans\ (\neg\ P_0(y),\ P_0(y)) \wedge (x \in\ Hum)$.

[x repairs y : $Ag(x,\ Trans\ (\neg\ P_0(y),\ P_0(y)) \wedge (x \in\ Hum)$].

The first part of the formula may be considered the opposite of (53) — the arguments of the functor *Trans* are reversed. The second part of the formula introduces the categorisation of x as a human being (damage may be done by forces of nature, yet in practice only a human being is capable of repairing something); this categorisation should perhaps be expanded to include automata ($x \in\ Hum \cup Aut$).

(55) x LECZY[1] y : $Ag(x,\ Trans(\neg\ P_0(y),\ P_0(y)) \wedge (x \in\ Hum) \wedge (y \in\ Anim)$.

[x CURES[1] y : $Ag(x,\ Trans(\neg\ P_0(y),\ P_0(y)) \wedge (x \in\ Hum) \wedge (y \in Anim)$.]

The formula describes one of the possible meanings of the verb *leczyć*, which pertains to actions performed by a human being upon a human being, an animal, etc. A very different formal notation would be needed to represent another meaning of the same verb exemplified in sentences such as: *Penicylina leczy zapalenie płuc* (penicillin cures pneumonia). The issue is made even more complex by the fact that even though (55) pertains to a singular x and y (with the assumption that the healing or treatment is effective), i.e. to sentences such as *Kowalski leczy Kozłowskiego* (Kowalski cures Kozłowski), the other meaning of the verb *leczyć* appears in more general sentences. It is not possible, however, to use a general quantifier ("for all z, if z has pneumonia, then..."), as this would result in false statements. Instead, it may be necessary to refer to the notion of probability; the sentence: *Penicylina leczy zapalenie płuc* (penicillin cures pneumonia) signifies that "if someone has pneumonia, it is very probable that penicillin will cure it."

Thus, we arrive at:

(56) x LECZY^2 $y : \bigwedge_{z} \bigvee_{i,j} P_y(z) \rightarrow$ *Prob* (*Ag* (x, *Trans* ($P_y(z)$, $P_0(z)$))), [i, j]) $\wedge$ *large* (i) $\wedge$ ($x \in$ *Med*) $\wedge$ ($y \in$ *Dis*) $\wedge$ ($z \in$ *Anim*),

[x CURES^2 y: $\bigwedge_{z} \bigvee_{i,j} P_y(z) \rightarrow$ *Prob* (*Ag* (x, *Trans* ($P_y(z)$, $P_0(z)$))), [i, j]) $\wedge$ *large* (i) $\wedge$ ($x \in$ *Med*) $\wedge$ ($y \in$ *Dis*) $\wedge$ ($z \in$ *Anim*)],

where *Med* is the set of medical substances. It is possible to avoid introducing the notion of the set *Dis* into the notation, if the part of the consequent in which it appears is substituted with ($P_y(z) \rightarrow \neg P_0(z)$) (the formula clarifies that the state P_y is an atypical state).

It may also be added that it would perhaps be more advisable to present a past-tense version of (55) — i.e. *x wyleczył y* (x cured y) — as it would imply that the action is assumed to be successful. If *x leczy y* is understood as: *x stara się o to, żeby y wyzdrowiał* (x makes an effort for y to recover), it needs to be interpreted as *x dąży do zrobienia tak, żeby y wyzdrowiał* (x aims at making y recover). Such an interpretation will be discussed in a later section, after the interpretation of the verb *dążyć* (to aim; understood as: to aim at achieving a specific result of one's actions) will be introduced.

(57) x SAMOREGULUJE SIĘ : $Trans_t(P_0\ (x), \neg\ P_0\ (x)) \rightarrow\ Ag_{t'}(x,$ *Trans* ($\neg\ P_0\ (x)$, $P_0(x)$)) $\wedge$ ($t < t'$).

[x SELF-ADJUSTS : $Trans_t(P_0\ (x), \neg\ P_0\ (x)) \rightarrow\ Ag_{t'}(x,$ *Trans* ($\neg\ P_0$ (x), $P_0(x)$)) $\wedge$ ($t < t'$).]

The interpretation of this formula requires some explanation in relation to the previously made remark on the changing of subscripts signifying

temporality. In the description of the functor *Trans* we have specified that its arguments signify states subsequent in time; in (57) the transition from one state to another appears over a specific (relative) period of time *t*. This leads to a problematic question of how this period of *t* relates to the temporal periods associated with the two states. The same problem arises in the case of interpreting the consequent of the implication, where a specific period of time *t'* (subsequent to *t*) is ascribed to the main functor *Ag*; the second argument of this functor is a sentence that involves the functor *Trans*, whose arguments, according to (5), are also associated with specific periods of time. To resolve this problem, the following interpretation is suggested: in this case (and other similar ones) it shall be assumed that the period of time *t* encompasses specific periods t_1 and t_2 ascribed to the arguments of the functor *Trans* in the antecedent of the implication in (57); similarly, the period of time *t'* encompasses specific periods of t'_1 and t'_2 ascribed to the arguments of the functor *Trans* in the consequent of the mentioned implication (here the functor *Trans* is an element of the functor *Ag*). Another suggestion is to stop marking the time periods t_1, t_2, etc., as this would make the notation rather unwieldy (the formula would look as follows: $Trans_t\ (P_0\ (x), \neg\ P_0\ (x)) \wedge (t_1 \subset^0 t) \wedge (t_2 \subset^0 t)$; the fact that $(t_1 < t_2)$ is implied in (5) and does not require stating, but even without it the formula would swell considerably) and to treat such an abbreviated notation as a convention.

The analyses presented above lead us to the following conclusions. Firstly, a comparison of (55) and (56) confirms the previously made remark that the meaning of a specific verb is, at least in some cases, heavily dependent on its arguments (if deeper semantic analysis is applied; such differences may go unnoticed if only the surface structure is analysed). Secondly, in the case of (57) the apparatus used throughout the study makes it possible to present the semantic interpretation of such new concepts as self-adjustment, which appears to be a proof of the considerable degree of universality of the mentioned apparatus.

The following section contains the analysis of verbs with an embedded argument of an instrument or an auxiliary substance. Such verbs are relatively numerous, and from the linguistic point of view there is no difference between an instrument and an auxiliary substance. The former group includes such verbs as *heblować* (to plane), *bronować* (to harrow), *kosić* (to scythe), *piłować* (to saw); the latter contains e.g. *lakierować* (to varnish), *politurować* (to cover with French polish). The English language abounds in such verbs, due to the phenomenon of 'conversion', related to the fact that in modern English the morphological boundaries between various parts of speech become

increasingly blurred (at least when it comes to basic forms). Conversion is, however, a broader phenomenon than the one under analysis. Moreover, the embedding of arguments is tackled differently in various languages: e.g. in Polish there are pairs such as *szczotka — szczotkować* (a brush — to brush), but a similar pair in the English language: 'a comb — to comb' is rendered into Polish as *grzebień — czesać* (the argument of instrument is not embedded in the verb); other examples include *pług — orać* (a plough — to plough). Conversely, the Polish *wiosło — wiosłować* becomes 'an oar — to row' in English. The issue may cause two major problems. The first is connected to identifying the SEMANTIC transitiveness of such verbs: *heblować* indubitably means 'to use a plane (a tool) on a given object', whereas *wiosłować* signifies 'to use an oar', with no direct reference to any other object. The assumption than the latter verb always refers to a boat being set in motion by the movement of oars is erroneous. Firstly, the use of a plane results in the modification of the object on which the tool is used — in the case of oars it is not so. Nor does the verb imply setting a boat in motion — in the case of the verbs *wiosłować* and *pedałować* (to pedal) one may easily find examples of training devices in which the motion of oars or pedals does not result in the translocation of the entire device or the training individual. Thus, it must be surmised that some of these verbs are semantically transitive, while others are not.

Another problematic issue is related to whether the formal notation of verbs such as *czesać* (to comb) or 'to row' should indicate that, semantically speaking, such verbs have arguments embedded in them, even though this is not apparent from the form of a given verb. It seems that various solutions may be adapted, depending on the possible practical needs.

Semantically transitive verbs with an embedded argument of an instrument or an auxiliary substance shall be represented with the following general formula:

(58) $xV_zy : Ag(x, R_1^2(x, z, y) \wedge Ag\ (x, P_z(y))$,

where the subscript z in $V_z$signifies an argument embedded in the verb, and V represents the verb; in the given case $V_z$represents the entire group of verbs under analysis. Interpretation: x acts so that there emerges a tripartite relation if using an instrument or an auxiliary substance; the relation exists between the agent x, the instrument or the auxiliary substance z and the object y towards which the action undertaken by x is directed; at the same time x acts so that the state of y is defined by z (in the sense that the object becomes polished, planed, etc.).

If we agreed to adopt a similar solution for the cases when the

argument is not embedded in the verb morphologically, but only semantically, such verbs would be represented by the following formula:

(59) $xV_{(z)}y : Ag(x, R_1^2(x, z, y) \wedge Ag(x, P_z(y))$.

The notation is very similar to (58) — the only difference consists in the addition of brackets around the subscript z in the *definiendum*.

For semantically intransitive verbs such as *wiosłować* (to row), the following notation may be used:

(60) $xV_z : Ag\ (x, R_z^1(z, x))$.

For verbs with an embedded argument of a different type, other solutions need to be adapted. For example, the verb *matkować* (to mother) may be represented as:

(61) xV_z *y-owi*: $Ag(x, R_z^1(x, y))$.

$[xV_z\ y$: $Ag(x, R_z^1(x, y))]$.

The interpretation is obvious: x acts so that between x and y there exists a relation determined by z.

The English verbs 'to coffin', 'to shelve' could be represented as:

(62) $xV_z\ y : Ag(x, R_z^1(z, y))$.

The notation states that as a result of the actions of x there exists a relation between y and z, determined by z. As mentioned in a previous section of the present study, the analysis pertains to non-metaphorical uses of verbs; the fact whether a given use is metaphoric or not often depends on the argument used in the expression — e.g. the phrase 'to shelve a proposal' exemplifies a metaphorical use of the verb 'to shelve'.

The English verb 'to knight' may be represented as:

(63) $xV_z\ y : Ag\ (x, P(y))$.

Interpretation: x acts so that the state of y is defined by z.

The English verb 'to ford' may be represented as:

(64) $xV_z\ y : Ag\ (x, R_z^1(x, y) \wedge (y \in\ Inland\ Waters)$.

Interpretation: x acts so that a relation determined by z begins to exist between x and y, where y belongs to the set of inland waters. The verb 'to ford' can also be described using a more complex formula, which illustrates the meaning more precisely:

(65) $xV_z\ y : \mathrm{V}\ u, wL(z, y) \wedge R_2^2(z, u, w) \wedge Ag\ (x, R_2^1(x, z) \wedge Ag\ (x, Trans(L(x, u), L(x, w)))$.

Interpretation: there exist such u and w that z is localised by y and that z lies between u and w, while x acts so that a physical contact between x and z is initiated, and x acts so that x moves from u to w (literally: acts so that its state determined by its location with regard to u is transformed into its state determined by its location with regard to w).

The above interpretation is certainly correct (it may also be extended to include the categorisation of y, i.e. a second element of the conjunction in the *definiens* of (64)), yet it is doubtful that it could be used for other semantically complex verbs with an embedded argument. In many cases it will definitely be necessary to discard the relatively schematic interpretations featured in formulas (58) — (64), especially since even in the case of the mentioned formulas the interpretations (although similar) are not strictly analogous. This hypothesis may be confirmed by further examples. The verb *prątkować* (meaning: 'to be capable of infecting others with *Mycobacteria*') may be represented as:

(66) $xV_z : P_z(x)$,

or, to be more precise:

(67) $xV_z : P_z(x) \wedge \neg\, P_0(x)$.

The verb *odprątkować* (meaning: 'to apply treatment that causes the patient to lose the ability to infect others with *Mycobacteria*; the verb is syntactically and semantically transitive) may be represented by the following formula, which takes into account not only the embedded argument, but also the prefix with a very definite meaning:

(68) $x\ deV_z\ y$: $Ag(x,\ Trans(\ P_z(y),\ \neg\ P_z(y)))$.

The verb *przeliterować* (meaning: to spell, to present the spelling of a word by pronouncing the letters in order) may be represented as:

(69) $xV_z\ y : \mathrm{S}(x,\ P_z(y)\ ) \wedge (y \in\ Inscription)$.

The English verb 'to dial' (a telephone number, etc.) may be represented as:

(70) $xV_z\ y : Ag(x,\ R^1_2(x,\ z)\ ) \wedge Ag\ (x,\ P_y(z)) \wedge (y \in\ code\ number)$.

Interpretation: x acts so that a physical contact is initiated between x and z and so that the state of z is determined by y. The situation in this case is exceptional, because as opposed to previous examples, it is the state of the instrument that is being determined (in the other examples the state of the object of the action was determined by the instrument). The above interpretation may, however, be considered questionable. Is it correct to state that the state of the telephone dial is determined by the number dialled by the person making the call? It appears so, with the proviso that the mentioned state is temporary, as opposed e.g. to the state of a wooden board determined by the action of covering it with varnish. Yet, given the fact that this issue is not reflected in the linguistic layer, but connected to our extra-linguistic knowledge, it does not seem necessary to include such considerations in linguistic semantic descriptions. It may be surmised that the differences in interpretation presented from formula (58) onwards is

sufficient for the purposes of linguistic descriptions. In the case of English, expressions such as 'to ford a river', 'to can food', 'to dial a number' are not varied in terms of syntax, i.e. do not contain purely linguistic differentiating data. As a result, it may be more advisable to substitute (70) with the following formula:

(71) $xV_z : Ag(x,\ R^1_z(z,\ x))$.

The emendations seem justified.

Another issue that requires attention is the need to differentiate between e.g. *Kowalski telefonuje*) and *Kowalski telefonuje, że...*The first expression conveys the message that Kowalski is busy speaking on the phone, while the second signifies that Kowalski is passing some information via telephone. In formal notation the two cases would be represented, respectively, as:

(72) $xV_z : Ag(x,\ R^1_z(z,\ x))$,

and

(73) xV_z (że) y: $Ag(x,\ R^1_z(z,\ x)) \wedge S(x,\ y)$.
$[xV_z$ (that) y: $Ag(x,\ R^1_z(z,\ x)) \wedge S(x,\ y)]$.

In this case one may also argue that even though in the case of *telefonować* the action is performed directly by the agent, with the verb *telegrafować* (to telegraph; in the sense of conveying messages, i.e. in the meaning expressed in (73)) the action itself is most often performed by somebody else, and thus *Kowalski telegrafuje* literally means 'Kowalski is causing someone to use the telegraph and (by means of this device) pass the information that... Again, however, it's a question of extra-linguistic knowledge. This claim is corroborated by the fact that if Kowalski himself is a telegrapher and sends his messages himself, the linguistic form of the expression used does not change.

Naturally, presenting a full description of all verbs is a task for the future; it would require a careful analysis of the entire list of verbs. It must also be remembered that various languages differ greatly in this respect, not only with regard to morphology. For example in the case of Polish and English the nouns *woda* and 'water' are lexically (and semantically) equivalent to one another, but the Polish verb *wodować* does not have a single Equivalent in English. Its various meanings can be rendered into English as 'to launch' (as in: to float a newly constructed ship), 'to alight on water' (of e.g. seaplanes) and 'to splash down' (of spacecrafts). In Polish the nominal argument is embedded in the verb, yet in English it is not so. The meaning of English verb 'to water', in turn, is rendered into Polish by two verbs, namely *podlewać* (to water a plant) and *poić* (to water a living creature). Thus, in

different languages the (approximate) semantic equivalents of verbs with embedded arguments may differ in terms of morphology and word-formation.

In many cases the nuances of meaning may result in interpretations that would be even more difficult to represent using the formal apparatus employed in the present analysis. E.g. the English expression 'to clock a person' (i.e. to measure the time in which a person is performing a given activity; often used to describe the actions of a coach with regard to a sportsperson) might be represented as:

(74) $xV_z\ y$: $\bigvee_u \bigvee_w Ag(y,\ u) \wedge (u = u(y)) \wedge Ag(x,\ R^1_z(z,\ x)) \wedge S(z,\ M(z,\ u,\ w))$.

Interpretation: y performs a certain activity u, x uses z and z indicates what measure w is determined for u.

The formulas may be even more complex in the case of such verbs as 'to time' and 'to space', where the embedded argument does not refer to a material object. Such problems shall be discussed in the future; their analysis may require revising or expanding some of the theoretical assumptions of the apparatus.

Verbs that may be characterised as creative are also problematic, especially since these verbs are used both in a creative and in a non-creative sense, depending on the structure of the sentence, and, most of all, depending on the category of the argument that in Indo-European languages appears as a direct object. One typical example is the verb *malować* (to paint) in such uses as *malować obraz* (to paint a painting) and *malować sufit* (to paint the ceiling). In the first case the action is creative, since the process of painting results in the emergence of a work of art. The latter case exemplifies a non-creative use — the ceiling was not made in the process of painting, but existed before. The two meanings can be represented using the following formulas which accentuate the differences by means of superscripts:

(75) x MALUJE^1 $y : Ag(x,\ Trans(\neg\ Ex(y),\ Ex(y)))$.
[x PAINTS^1 $y : Ag(x,\ Trans(\neg\ Ex(y),\ Ex(y)))$].

(76) x MALUJE^2 $y : VzAg(x,\ R^2_1(x,\ z,\ y)) \wedge Ag(x,\ P_z(\mathrm{y}))$.
[x PAINTS^2 $y : VzAg(x,\ R^2_1(x,\ z,\ y)) \wedge Ag(x,\ P_z(\mathrm{y}))$].

In the latter case, as with the verb *czesać* (to comb), we are assuming that the argument — referring to an auxiliary substance, not an instrument — is semantically embedded in the verb *malować* (this is very apparent in the English equivalent 'to paint'), which determines the details of the notation. The semantic differences between the two meanings of the Polish verb find confirmation in word-building; the perfective form of the verb may either be *namalować* or *pomalować*, depending on which meaning is implied.

The reflexive verb *malować się* also has at least two basic meanings: to cover one's body or a part of it with paint (used in relation to makeup, markings on the skin made by warriors before a battle, etc.) or to be visible as (a) an element of the landscape or (b) as a reflection of an emotion on a person's face. The latter meaning shall not be discussed in the present analysis; it is a near equivalent of the meaning of the verb *widnieć* = 'to be visible to somebody' and requires a locative identification.

(77) x MALUJE SIĘ^1: $\bigvee_z \bigvee_{x'}(x' \subset^{o} x) \wedge Ag(x, R_1^2(x, z, x') \wedge Ag(x, P_z(x'))$.

[x PAINTS ITSELF^1: $\bigvee_z \bigvee_{x'}(x' \subset^{o} x) \wedge Ag(x, R_1^2(x, z, x') \wedge Ag(x, P_z(x'))$.]

This notation is almost identical with *maluje*^{2}, the only difference being the substitution of y with x' (signifying a part of x). The Polish language accentuates the differences in the meanings of this verb in word formation: the perfective form of the verb *malować się* in the discussed meaning is *umalować się* (though in the case of warriors painting their bodies *pomalować się* also seems acceptable; yet such uses are rare in Polish and refer to situations alien to our culture). The verb *malować się*^{2} used in the meaning (a) practically never appears in a perfective form, but in the case of the meaning (b) the appropriate form is also different — *odmalować*. (These remarks on word formation pertain to the Polish language and, as such, diverge from the basic premise of the present work, yet it seems justified to include them, since they confirm the existence of semantic differences between the various uses of the verb under analysis).

As for the verb *budować*, the present analysis shall disregard the expression *budować coś na czymś* (to build something on something) in its metaphorical uses such as *Kowalski buduje swoje nadzieje na tym, że ma ustosunkowanego przyjaciela* (Kowalski is building his hopes on the fact that he has a well-connected friend), since the author of the present work considers this to be an example of the use of the verb *budować na* (to build on), where the preposition *na* is a crucial element of the verb in the discussed meaning. In its basic meaning the verb may be represented analogously to *malować*^{1}:

(78) x BUDUJE y : $Ag(x, Trans(\neg\, Ex(y), Ex(y)))$.

[x BUILDS y : $Ag(x, Trans(\neg\, Ex(y), Ex(y)))$].

The verb *budować się* has at least two meanings: *budować się*^{1} = to be built; *budować się*^{2} = to be building (e.g. a house) for oneself.

(79) x BUDUJE SIĘ^1: $\bigvee_y$ textitAg(y, $Trans(\neg\, Ex(x), Ex(x))$).

[x IS BEING BUILT: $\bigvee_y Ag(y, Trans(\neg\, Ex(x), Ex(x)))$.]

Incidentally, the fact whether this constitutes a correct minimal sentence is a matter of discussion: it appears that an additional element (specifying the location, the number, etc.) may be necessary both in Polish and in other languages.

(80) x BUDUJE SIĘ^2 : $\bigvee_y Ag(x, Trans(\neg Ex(y), Ex(y))) \wedge Ag(x, R_1^1(x, y))$.

[x IS BUILDING STH FOR ONESELF : $\bigvee_y Ag(x, Trans(\neg Ex(y), Ex(y))) \wedge Ag(x, R_1^1(x, y))$.]

In this case x is building y and at the same time acts so that a relation of ownership is created between x and y. Thus, the verb *budować* appears to be semantically rich. In the Polish language, if the object being built is mentioned in the sentence, the verb takes the form *budować sobie*, e.g. *Kowalski buduje sobie willę nad zalewem* (Kowalski is building himself a villa by the reservoir). This example is even more complex, as it specifies the location of the building. In formal notation it could be represented as follows:

(81) x BUDUJE SOBIE y (W) z : $Ag(x, Trans(\neg Ex(y), Ex(y))) \wedge Ag(x, R_1^1(x, y)) \wedge L(y, z)$.

[x IS BUILDING THEMSELVES y (IN) z : $Ag(x, Trans(\neg Ex(y), Ex(y))) \wedge Ag(x, R_1^1(x, y)) \wedge L(y, z)$.]

In the abovementioned Polish example "(w)" represents the entire class of locative prepositions. As the rules of description adhered to in the present study suggest, the final element of the conjugation in formula (81) should be semantically interpreted as identifying location; the surface structure of the component is irrelevant (in some cases and/or languages the expression may not contain a preposition at all).

Verbs with a creative meaning such as *malować*^{1} (to paint) or *pisać* (to write) may also be used in the so-called absolute sense, e.g. *Kowalski maluje* as in: "Kowalski is busy painting." In such cases the speaker is referring to the state Kowalski is in, therefore it would theoretically be possible to interpret the verb as follows:

(82) x MALUJE^1 : $\bigvee_i P_i(x)$.

[x PAINTS^1 : $\bigvee_i P_i(x)$.]

On the other hand, the action results in the creation of an object, so the following interpretation is also acceptable:

(83) x MALUJE^1 : $\bigvee_y Ag(x, Trans(\neg Ex(y), Ex(y)))$.

[x PAINTS^1 : $\bigvee_y Ag(x, Trans(\neg Ex(y), Ex(y)))$.]

This formula features the typical variable y bound to the quantifier of existence, indicating that y, i.e. the object created as a result of the given activity, is not explicitly mentioned in the sentence. Since there are languages which have a tendency to avoid such absolute uses and mention the result of any given action (in modern Chinese the tendency has entered into the realm of lexicalising processes) even if the use resembles our absolute uses, the latter of the abovementioned interpretations appears more accurate, especially given the fact that it indicates the creative nature of the activity performed by x.

The difficulties of semantic analysis may be illustrated using the (digressive) example of the elements traditional grammar dubs 'adverbials of manner'. Let us consider the following two sentence: *Kowalski ładnie maluje* (Kowalski paints nicely) and *Kowalski szybko maluje* (Kowalski paints fast). Despite all appearances, the "adverbials of manner" used in the sentences (*ładnie* and *szybko*) differ in terms of semantic interpretation. The former constitutes an evaluation of the result of an activity, whereas the latter refers to the evaluation or a measurement of the process itself. The first example sentence may be interpreted as follows:

(84) x ładnie MALUJE^1 : $\bigvee_y \bigvee_i \bigvee_z Ag(x, Trans(\neg\ Ex(y),\ Ex(y)) \rightarrow (P_i(y) \wedge V(s,\ P_i(y),\ z) \wedge (z > 0) \wedge (z \in Aesth))$.

[x PAINTS^1 nicely : $\bigvee_y \bigvee_i \bigvee_z Ag(x, Trans(\neg\ Ex(y),\ Ex(y)) \rightarrow (P_i(y) \wedge V(s,\ P_i(y),\ z) \wedge (z > 0) \wedge (z \in Aesth))$].

Interpretation: if x paints something (in the creative sense), then the product of this activity is positively evaluated by the speaker, and the evaluation is aesthetic in character (it belongs to the realm of aesthetic evaluation). The *definiens* is represented as an implication, because sentences of this type are frequently uttered when discussing someone's skill without making references to the activities the person is currently engaging in.

The latter example (*Kowalski szybko maluje*) is much more difficult to interpret, yet it is apparent that the meaning of the phrase is different than in the previous example: in this case the speaker is evaluating or measuring the time that elapses between the start and the end of a given action (the speaker may mean two different things: (a) the speed of the action, or, if the action cannot be performed at one stroke, (b) the fact that the breaks between the successive stages of the activity are relatively short). To represent the example in formal notation, the apparatus would have to be extended to include at least the definitions of starting and finishing an activity. As we said before, the above considerations are merely a digression,

since the problem concerns not verbs as such, but adverbials.

The verb *pisać* may be interpreted analogously to *malować*[1]. *Pisać się* proves much more problematic, as this reflexive verb has acquired many meanings in the Polish language. We shall disregard the expression *pisać się na coś*, since it is semantically equivalent to *mieć na coś ochotę* (to have a fancy for something) and is a stylistic variation of the phrase *chcieć coś posiąść* (to wish to own something) or *chcieć się znaleźć w określonej sytuacji* (to wish to be in a given situation). Moreover, in the Polish language *pisać się na* may be considered a compound phrase, i.e. a different verb. The specific use of the reflexive form in third person singular, as in the sentence: *Kowalskiemu dobrze się pisze* (perhaps more frequent in first person singular, in sentences such as *dobrze mi się pisze*) is unique to the Polish language; there is no exact equivalent of this surface structure in other languages. For this reason, it often cannot be translated into a concise phrase. The meaning of the expression is also difficult to capture. Usually the phrase *Kowalskiemu dobrze się pisze* signifies that (a) Kowalski is satisfied with the effects (results) of his writing, or that (b) he is satisfied with the circumstances in which he is writing. Such phrases usually appear in a more complex form — the sentence also specifies the time frame or location, e.g. *dobrze mi się dziś pisze* (I am satisfied with my writing today), *dobrze mi się tutaj pisze* (roughly translatable as: I am satisfied with my writing here), etc. A formal interpretation would have to take all the abovementioned semantic nuances into account — it shall not be discussed in the present analysis due to its spatial constraints.

The verb *pisać się* in its meta-linguistic meaning (i.e. signifying: to be subject to certain rules of spelling) is also a specialised one. The Polish sentence *analizuje pisze się przez u* is equivalent e.g. to the English 'analyse is spelled with a *y*' — an expression containing a semantically specialised verb 'to spell'. In both cases the semantic interpretation of the example sentence would be as follows:

(85) x PISZE SIĘ (przez) $y : P_0(x) \rightarrow ((y \subset^{o} x) \wedge (x \in \mathit{Writ}) \wedge (y \in \mathit{Writ})$.

[x IS SPELLED (with) $y : P_0(x) \rightarrow ((y \subset^{o} x) \wedge (x \in \mathit{Writ}) \wedge (y \in \mathit{Writ})$].

Interpretation: if x is in its standard state, then y is a part of it, and both x and y are elements of a given graphic code or sub-code.

The expression *pisać się* used in its vernacular meaning, e.g. in such sentences as *on się pisze Kowalski* signifies that in official documents a given person is referred to as 'Kowalski' (even though in everyday life he is called

something else). It may be represented by the following formula:

(86) x PISZE SIĘ y: $R^1_1(x, y) \wedge (x \in \mathit{Human}) \wedge (y \in \mathit{Name})$.

[x IS REFERRED TO AS y: $R^1_1(x, y) \wedge (x \in \mathit{Human}) \wedge (y \in \mathit{Name})$].

In this case the relation of possession is limited with additional categorial conditions placed on its arguments: x needs to be a person (and not e.g. a legal entity) and y must be a name.

Unexpectedly, perhaps, the verb *czytać* (to read) is not easy to interpret. The verb is decidedly polysemantic. It has metaphorical uses, in which *czytać* signifies 'to guess, to speculate, to interpret', e.g. in: *czytać czyjeś myśli* or *czytać w czyichś myślach* (both meaning: to read somebody's mind), *czytać coś w czyjejś twarzy* (to read something in somebody's face), etc. Other frequent uses include phrases like *czytam, ale nie rozumiem* (i can read this but I don't understand). Thus, the verb *czytać* may mean: to guess, to interpret, to see (to look at) a given text, to see a text and identify its elements, to see a text and understand it (interpret it semantically), or — which is a new meaning referring to electronic devices — to identify the elements of a given text with the use of mechanisms imitating sight. The understanding of a text is not the *sine qua non* condition of reading: if it was so, the verb *czytać* could not be used in reference to electronic devices, nor would we be able to say *czytam, ale nic z tego nie rozumiem* (I am reading this, but can't understand a word from it). To complicate matters even more, the verb *czytać* may also be used in reference to blind people decoding texts written in the Braille alphabet — thus, sensory or even quasi-sensory (electronic scanners) reception of visual (or quasi-visual) nature cannot be considered a necessary condition. The suggested interpretation is therefore very general, yet convenient, as it appears to cover all the meanings of the verb *czytać* listed above:

(87) x CZYTA $y : \bigvee_z R^1_2(x, y) \wedge \mathit{Exp}(x, R^1_6(y, z)) \wedge (y \in \mathit{Writ}) \wedge R^1_7(x, z)$.

[x READS $y : \bigvee_z R^1_2(x, y) \wedge \mathit{Exp}(x, R^1_6(y, z)) \wedge (y \in \mathit{Writ}) \wedge R^1_7(x, z)$.]

By disregarding the requirement that $(y \in \mathit{Writ})$, we arrive at the interpretation of the verb *czytać* in at least some of its metaphorical uses.

Verbs referring to sensations may be represented using the following model:

(88) $x\ V_{sens}$(że) $y : \mathit{Exp}(x, y)$.

[$x\ V_{sens}$(that) $y : \mathit{Exp}(x, y)$].

The model utilises the functor *Exp* (cf. formula (13)). This is, however, only the most basic formula, which may be modified depending on specific

needs. Firstly, the functor *Exp* is defined in a such a way that its second argument is a sentence (hence the inclusion of the element *że/that* in the *definiendum* of (88)). This may require emendation in cases where the sensation is expressed with a proper name — such surface structures are very common, at least in Indo-European languages. Secondly, some verbs referring to sensations clearly indicate the organ involved. Different languages tackle this issue differently. Polish distinguishes between *widzieć* (to see) and *słyszeć* (to hear), whereas Italian and Ukrainian contain equivalents only for the former verb. The English language contains specific verbs such as 'to see', 'to hear', 'to smell' and 'to taste'; only the verb 'to feel' (which encompasses tactile sensations, but is not limited to this sense) is not specific and resembles the Polish *czuć*. It seems justified to mark any indication of the organ involved in the formula whenever it is implied in the meaning of the verb.

Verbs indicating the sensory organ may be represented as:

(89) $x\ V_{sens'}(\text{że})\ y : \bigvee_{x' \subset^0 x} Exp(x,\ y) \wedge R^1_2(x',\ y)$,
$[x\ V_{sens'}(\text{that})\ y : \bigvee_{x' \subset^0 x} Exp(x,\ y) \wedge R^1_2(x',\ y),]$

where *x'* represents the sensory organ (or, more precisely, a body part of) *x*, $R^1_2$is a constant (cf. (26)) and the apostrophe by *sens* indicates that the verb in question contains a reference to the organ involved.

Expressions in which the object of sensory perception is specified, e.g. *Kowalski widzi dom* (Kowalski is seeing a house) cannot be considered verbs, since e.g. in the Polish language acceptable forms include both *Kowalski widzi dom* and *Kowalski widzi, że...* (Kowalski sees that...). In such cases it is necessary to regard the second argument of the functor *Exp* as a sentence. This is due to the fact that upon seeing a house we also see how it looks like. The proposed formula (in which *y* is a proper name in the expression specified in the *definiendum*) is as follows:

(90) $x\ V_{sens'}\ y : \bigvee_i Exp(x,\ P_i(y))$.

If the verb specifies the sensory organ involved, the notation should be expanded to:

(91) $x\ V_{sens'}\ y : \bigvee_i \bigvee_{x' \subset^0 x} x\ Exp(x,\ P_i(y) \wedge R^1_2(x',\ y))$.

For sentences such as *Kowalski czuje, że swędzi go ręka* (Kowalski feels that his hand is itching), we arrive at:

(92) $x\ V_{sens'}\ (\text{że})\ y : \bigvee_i \bigvee_{x' \subset^0 x} (y = P_i(x') \wedge Exp(x,\ P_i(x')) \wedge Exp\ (x, \neg P_0(x'))$.

Interpretation: x experiences that a part of x's body is in a certain non-standard state.

The verbs *widzieć* (to see) and *słyszeć* (to hear) — and presumably also their equivalents in other languages — have an additional specialised meaning rarely compared to that of *czuć* (to feel) and other verbs referring to sensations without specifying the organ involved, namely 'to have the ability of sight/hearing' or even 'to regain sight/hearing'. To analyse such meanings we would have to start with interpreting potential states, therefore no complete formula may be presented at this point. In any case, such expressions are usually heavily dependent on the context.

To emphasise that the sensations are experienced by x consciously, the following formula may be used:

(93) x *świadomie* V_{sens} y : $Exp(x, Exp\ (x, y))$,
[x *consciously* V_{sens} y : $Exp(x, Exp\ (x, y))$,]

which means that: x is experiencing that x is experiencing (that) y.

Verbs signifying measurement and/or calculation may be represented generally as:

(94) $x\ V_m\ y : \bigvee_z M(x, y, z)$.

The model refers simply to the functor M (cf. (15)), but in this case y may also stand for numerical data of a given calculation — in such situations the measurement is the result of the calculation. It may also be assumed that in the case of verbs signifying mathematical operations y is the description of the procedure that is to be done. Thus, the sentence *Kowalski dodaje dwa do trzech* (Kowalski is adding two to three) would be equivalent to 'Kowalski is adding: 2 + 3' and, at a later stage of interpretation, to 'Kowalski is establishing the measurement for 2 + 3'. The method may seem rather unnatural, yet the apparatus of the present analysis is not suited for interpreting verbs describing mathematical operations, even though it has proved effective for other verbs. Verbs whose meaning includes mathematical operations are very difficult to interpret, especially since the most basic operations (e.g. addition) are designated by verbs that have other, non-mathematical meanings (the Polish verb *dodać* — to add may also signify 'to say something more', 'to give something more' etc.). The use of the functor M shall, at least for the time being, be limited to the description of the mathematical meanings of the verbs in question.

Verbs of measurement such as *ważyć* (to weigh) and *mierzyć* (to measure) are semantically transitive; the same applies to such verbs as *rachować* (to count), which may also be used without an object — in such cases the emphasis is placed on the action itself. *Kowalski rachuje* (Kowalski

is counting) is equivalent to 'Kowalski is busy with counting (something)'.

The verbs *ważyć* (to weigh), *mierzyć* (to measure), *liczyć* (to count) carry another meaning, which may generally be defined as: to have a specified measure of a given type'. This use may be exemplified by sentences such as *Kowalski waży 58 kilo* (Kowalski weighs 58 kilos), *Kowalski mierzy 185 centymetrów* (Kowalski measures 185 centimetres), *Warszawa liczy milion trzysta tysięcy mieszkańców* (Warsaw has one million three hundred thousand inhabitants; the number of inhabitants is regarded as the measure of the city's size), *Mongolia liczy milion kilometrów kwadratowych powierzchni* (Mongolia extends over one million square kilometres). In such cases the measure must be specified in the surface structure. If we represent such obligatory measurements as m_i, the example sentences may be interpreted as:

(95) $x\ V_m\ m_i : M(s, x, m_i)$.

This interpretation implies that it is the speaker who assigns a given measure to x.

Sentences such as *Kowalski się waży* (Kowalski is weighing himself) may be represented as:

(96) $x\ V_{m,efl} : \bigvee_y M(x, x, y)$.

Sentences such as *Kowalski daje się zważyć* (Kowalski is letting himself be weighed) could be represented with the following formula:

(97) $x\ V_{mpermiss}: \bigvee_y \bigvee_z Ag(x, M(y, x, z))$.

Examples (96) and (97) can also serve as the model for interpreting semantically reflexive verbs and the so-called 'permissive' verbs (x is letting themselves be V).

Sentences such as *Kowalski mierzy stół centymetrem* (Kowalski is measuring the table with a tape measure) may be represented as:

(98) $x\ V_m\ y$ (za pomocą) $z: \bigvee_w Ag(x, R_1^2(x, z, y) \wedge M(x, y, w)$,

$[x\ V_m\ y$ (using) $z: \bigvee_w Ag(x, R_1^2(x, z, y) \wedge M(x, y, w)]$,

where R_1^2 is a constant (cf. (32)).

The final sub-group to consider in this section are 'measure' verbs with an embedded argument (most verbs in this category pertain to mathematical operations). Examples in the Polish language include: *sumować* (to sum), *potęgować* (to exponentiate), *pierwiastkować* (to extract the n^{th} root), *logarytmować* (to logarithmise), *różniczkować* (to differentiate), *całkować* (to integrate), etc. They can be represented as:

(99) $x\ V_{mz}\ y: \bigvee_w M(x, y, w) \wedge R_z^1(w, y)$.

Another (relatively small) group of verbs for which a general formula may be devised includes performative verbs such as *chrzcić* (to christen), *błogosławić* (to bless), *przeklinać* (to curse), *wyświęcać* (to ordain), which usually contain an embedded argument (also: *nadawać imię* — to name — which is semantically a performative verb). The notation is as follows:

(100) $x\ V_{perfz}y : (S\ (x,\ P_z(y)) \leftrightarrow\ Ag(x,\ P_z(y)) \wedge (x \in\ Hum).$

Interpretation: informing that y is in a state delineated by z is equivalent to acting so that y be in a state delineated by z. This act of informing does not have to be verbal, it may also consist of a sequence of gestures with a given semantic value. It appears that the apparatus devised for the present work easily lends itself to interpreting verbs that have only recently become the subject of analysis and were causing certain theoretical difficulties.

Apart from performative verbs, languages also contain verbs with performative uses (which also have other, non-performative meanings). This category may be exemplified with *otwierać* (to open) and *zamykać* (to close) in such sentences as: *Otwieram posiedzenie Rady Wydziału* (I hereby open the session of the faculty council). In these cases the announcement (the uttering of a specific formula) itself creates a certain legal condition. Such uses are more difficult to describe with the formal apparatus employed in the present work. This is because the principles adopted in our analysis gravitate towards reistic interpretation — due to reasons that are practical rather than theoretical, let alone philosophical in nature. A certain reistic interpretation of nouns such as *posiedzenie* (a session), *zebranie* (a meeting), *zawody* (a contest), *wystawa* (an exhibition), *zjazd* (a gathering), *konferencja* (a conference) would have to be presented before any sentence in which they appear could be represented in formal notation. This reistic approach may perhaps be abandoned in the course of future research (especially given the fact that even the present work cannot adhere to it fully — the concepts of measure and value, i.e. the third arguments of the functors M and V do not comply with this condition); in this case some problems would no longer be an issue. For the time being we may propose the following tentative interpretation of sentences with verbs that have performative uses but are generally used in a non-performative manner:

(101) $x\ V_{perfi}y : \bigvee_w \bigvee_j \mathrm{P}_j\ (w) \wedge ((S\ (x,\ P_j(w) \wedge P_i(w))) \leftrightarrow\ (Ag(x,\ P_j(w) \wedge P_i(w)))) \wedge (w \in\ Hum) \wedge (x \in\ Hum).$

Interpretation: the subscript i by the symbol of the performative verb in the *definiendum* indicates which verb (used in its performative meaning) is being analysed; the formula does not feature the subscript z because it

would be difficult to interpret the verb as having an embedded argument. It is assumed that performative uses within the group of verbs under analysis always pertain to human beings (or anthropomorphised objects) in a specific state (usually it is the state of being gathered in a certain place); the performative use pertains to a certain other state of the said human beings related to the pervious state (e.g. if the people are at a stadium, the announcement of the tournament being open is equivalent to the opening of the said event). The interpretation is rather complicated — as noted above, it may later be simplified if alterations in the basic premises of interpretation are made.

Let us now proceed to interpret verbs that cannot be categorised as distinctive groups (at least in the sense of being able to present a general formula featuring V and a subscript). First we shall discuss verbs related to location.

Verbs such as *znajdować się* (+ prep) (to be located), *biec* (often + prep) (to run — of rivers, roads, etc.), *leżeć* (+ prep) (to lie), where '+ prep' signifies the use of a locative preposition (in the Polish language), may be represented as:

(102) x ZNAJDUJE SIĘ (prep) $y : L(x, y)$.

[x IS LOCATED (prep) $y : L(x, y)$].

Formulas for the other abovementioned verbs would be analogous, with the reservation that in the case of *biec* x must belong to a class of material or linear objects such as *droga* (a road), *linia kolejowa* (a railway line), *autostrada* (a highway), *szosa* (a lane), *rurociąg* (a pipeline), *linia wysokiego napięcia* (a high-voltage line) or conceptual objects such as *granica* (a border), *trasa* (a route). In the Polish language the verb *biec* may be used without any preposition, e.g. in *droga biegnie doliną* (the road runs through a valley).

For such verbs it is semantically mandatory to add a component specifying location; in some cases these components take such a form that it is possible to interpret them as referring to the manner of construction, yet locative interpretation is never out of the question (e.g. in the case of *rurociąg biegnie pod ziemią* — the pipeline runs underground — the expression *pod ziemią* means 'under the surface of the ground', so it is possible to view it in terms of location with regard to the surface of the ground).

(103) x MIESZKA (prep) $y : \bigvee_z R_4^1(x, z) \wedge L(z, y) \wedge (x \in Hum)$.

[x LIVES (prep) $y : \bigvee_x R_4^1(x, z) \wedge L(z, y) \wedge (x \in Hum)$.]

The introduction of z may seem surprising or even redundant, yet it is a deliberate and perhaps even necessary step: a person stating that *Kowalski mieszka w Krakowie* (Kowalski lives in Cracow) means that Kowalski is

living in some flat located in Cracow. It is therefore necessary to include the element z representing this flat. Locating x directly with regard to y is not justified, because having a flat does not imply permanent location, i.e. constant presence in the said flat. The relation $R_4^1$is a constant (cf. (28)).

Sentences such as *Kowalski mieszka wygodnie* (Kowalski lives comfortably), *Kowalski mieszka w czteropokojowym mieszkaniu* (Kowalski lives in a four-room flat), etc. require a separate formula — they refer to the *modus habitandi* rather than to *locus habitandi* (even though the latter sentence contains the seemingly locative preposition w). It must be remembered that in the case of the verb *mieszkać* (to live) specifying the place or manner of living seems semantically obligatory. Thus, such examples may be interpreted as follows:

(104) x MIESZKA y-OWO : $\bigvee_z R_4^1(x, z) \wedge P_y(z) \wedge (x \in Hum)$.

[x LIVES y-like : $\bigvee_z R_4^1(x, z) \wedge P_y(z) \wedge (x \in Hum)$.]

(105) x MIEŚCI się (prep) y : $\bigvee_z R_4^1(x, y) \wedge L(x, y) \wedge (x \in Inst)$.

[x IS LOCATED (prep) y : $\bigvee_z R_4^1(x, y) \wedge L(x, y) \wedge (x \in Inst)$].

It appears that this verb needs to be interpreted differently than *mieszkać*, since the connection between an institution and its seat is locationally permanent, at least for a given period of time.

The following section of the present analysis contains the interpretation of several verbs related to the change of location, yet considered from the perspective of location and not the movement itself.

(106) x UDAJE SIĘ (prep) y : $\bigvee_z Ag(x, Trans(L(x, z), L(x, y)))$.

[x GOES (prep) y : $\bigvee_z Ag(x, Trans(L(x, z), L(x, y)))$.]

In this case it is semantically mandatory to specify the destination.

(107) x OSIEDLA SIĘ (prep) y : $Ag(x, L(x, y)) \wedge Ag(x, R_4^1(x, y)) \wedge (x \in Hum)$.

[x SETTLES (prep) y : $Ag(x, L(x, y)) \wedge Ag(x, R_4^1(x, y)) \wedge (x \in Hum)$].

(108) x PRZENOSI SIĘ (z) y (do) z : $Ag(x, Trans(R_4^1(x, y), R_4^1(x, z))) \wedge (x \in Hum)$.

[x RELOCATES (from) y (to) z : $Ag(x, Trans(R_4^1(x, y), R_4^1(x, z))) \wedge (x \in Hum)$].

The above interpretation covers both meanings of the verb *przenosić się*: the first meaning refers to the change in the place of residence; the second — to a change e.g. of the place of work. To ascertain the meaning of the verb in any given case, one needs to refer to the meanings of the arguments y and z.

(109) x EMIGRUJE (z) y (do) $z : \bigvee_{u,w} Ag(x, \neg R_4^1(x, y)) \wedge Ag(x, R_4^1(x, z)) \wedge V(x, y, u) \wedge V(x, z, w) \wedge (w > u) \wedge (u < 0) \wedge (y, z \in Country)$.

[x EMIGRATES (from) y (to) $z : \bigvee_{u,w} Ag(x, \neg R_4^1(x, y)) \wedge Ag(x, R_4^1(x, z)) \wedge V(x, y, u) \wedge V(x, z, w) \wedge (w > u) \wedge (u < 0) \wedge (y, z \in Country)$].

The details of this interpretation may raise some doubts; one may for example question the necessity of u being negative — perhaps it would be sufficient to specify that u is smaller than w.

What is more, in some sentences with the verbs *przenosi się* and *emigruje* the argument y is not stated explicitly, since the emphasis is put on z as the destination. In such cases In such cases y must appear in the *definiens* as a variable bound to the quantifier of existence.

In the case of *emigrować*, the first two elements of the conjugation should perhaps be extended to: $Ag(x, Trans(R_4^1(x, y), \neg R_4^1(x, y)))$ and $Ag(x, Trans(\neg R_4^1(x, z), R_4^1(x, z)))$, which would clearly point to x ending its formal contact with country y and establishing such contact with country z. It would perhaps be more advisable to substitute the two elements with the notation introduced earlier in the interpretation of the verb *przenosić się* and keep the latter part of the formula (i.e. the indication that z is evaluated more positively by x and that both y and z are countries).

Problems such as the one discussed above in connection with the verb *emigrować* clearly illustrate the difficulties that may arise in the process of formal verb description; yet such issues discredit neither the principles nor the value of formal description. In some cases the problems only reflect our imperfect understanding of certain verbs, which becomes apparent during attempts at specifying their meaning.

This may be a good opportunity to demonstrate that the apparatus adapted for the purposes of the present study is sufficient to interpret at least some occasional locative expressions:

(110) x PRZYBYŁ tutaj : $\bigvee_{y,z} Ag(x, Trans(L(x, y), L(x, z)) \wedge L(s, z) \wedge (x \in Hum)$.

[x CAME here : $\bigvee_{y,z} Ag(x, Trans(L(x, y), L(x, z)) \wedge L(s, z) \wedge (x \in Hum)$].

(111) x ODSZEDŁ stąd : $\bigvee_{y,z} Ag(x, Trans(L(x, y), L(x, z)) \wedge L(s, y) \wedge (x \in Hum)$.

[x LEFT this place: $\bigvee_{y,z} Ag(x, Trans(L(x, y), L(x, z)) \wedge L(s, y) \wedge (x \in Hum)$].

(112) x UDAŁ SIĘ tam : $\bigvee_{y,z} Ag(x,\ Trans(L(x,\ y),\ L(x,\ z)) \wedge \neg\ L(s,\ z) \wedge (x \in\ Hum)$.

[x WENT there : $\bigvee_{y,z} Ag(x,\ Trans(L(x,\ y),\ L(x,\ z)) \wedge \neg\ L(s,\ z) \wedge (x \in\ Hum)$].

In the case of the verb *odszedł* the formula refers to the general meaning of 'leaving the place', without specifying the mode of transport (in Polish the verb could also imply walking away). The occasional nature of the expression is emphasised by the reference to the speaker. For the sake of clarity, in the examples chosen for the present analysis $x \in\ Hum$ and is the agent of the action. It would, however, be possible to choose other examples in which x would not be the agent — in such cases the first element of the conjunction would be limited to $Trans(L(x,\ y),\ L(x,\ z))$. The matter has no bearing on the notation of the occasional elements of utterances. Example (112) only provides information in a negative way: *tam* (there) is understood merely as 'not here' with regard to the speaker. This does not, however, seem to be a fault of the formal apparatus: the word *tam* is used either anaphorically, i.e. in relation to a previously mentioned location, or deictically (ostensibly) by extra-linguistic means (i.e. not using any natural language but making a gesture). The forms of communication that go beyond the channel of natural languages cannot be taken into consideration in a work concerned with the semantic interpretation of utterances made in a natural language.

The following section shall contain the analysis of (broadly understood) verbs of movement. It should be noted that auto-agentive verbs (i.e. ones in which the result of the action performed by x affects x themselves) are semantically reflexive irrespective of whether this reflexivity is expressed grammatically or not.

(113) x IDZIE: $\bigvee_{y,z}\ \bigvee_{i} Ag(x,\ Trans(L(x,\ y),\ L(x,\ z))) \wedge P_i(x) \wedge (x \in\ Anim)$.

[x WALKS: $\bigvee_{y,z}\ \bigvee_{i} Ag(x,\ Trans(L(x,\ y),\ L(x,\ z))) \wedge P_i(x) \wedge (x \in\ Anim)$].

In this case the state P_i signifies that the movement is made on foot and in a given fashion: the verb *iść* needs to be distinguished from *biec* (to run), *pływać* (to swim), *skakać* (to jump), *czołgać się* (to crawl), *pełzać* (to slither), *lecieć* (to fly; in relation to birds), etc. It is a closer equivalent to the English verb 'to walk' that 'to go', the meaning of which is often more similar to that of *udawać się (do)*, with the mode of transport specified only by the context.

The environment in which movement occurs (the ground, water,

air) may be indicated by defining the state of x. This method does not necessitate any emendation in the conceptual apparatus adopted in the present analysis. In future research it will be possible to indicate a given situation by introducing fixed (i.e. not variable) subscripts and superscripts to be added to P (as in the case of the relations discussed in the introduction).

Verbs such as *pchać* (to push), *przesuwać* (to shift), *przenosić* (to move — referring to a physical object) may be represented as:

(114) x PRZESUWA $y : \bigvee_{w}, z\ Ag(x, Trans(L(y, w), L(y, z)))$.

[x MOVES $y : \bigvee_{w}, z\ Ag(x, Trans(L(y, w), L(y, z)))$.]

Verbs such as *przepędzać*, *przeganiać* (both mean: to drive, e.g. cattle) can be represented as:

(115) x PRZEPĘDZA $y : \bigvee_{w,z} Ag(x, Ag(y, Trans(L(y, w), L(y, z))) \wedge (x \in Anim) \wedge (y \in Anim)$.

[x DRIVES $y : \bigvee_{w,z} Ag(x, Ag(y, Trans(L(y, w), L(y, z))) \wedge (x \in Anim) \wedge (y \in Anim)$].

Interpretation: x acts so that y moves in an auto-agentive manner. Naturally, if the *definiendum* of (114) or (115) contains locative elements w and/or z, they should not be bound to any quantifiers in the *definiens*.

The Polish verb *zapędzać* (to drive into) semantically requires the destination to be specified (in non-metaphorical uses; metaphorical ones may be less precise, e.g. *zapędzać do roboty* — to drive to work, to force to work). This need is usually reflected in the surface structure, with the exception of situations in which the destination is clear from the context. The use of the verb *odpędzać* (to drive off) suggests a movement away from the speaker, if the 'starting point' is not specified explicitly (similarly to *opędzać się od...*, which clearly signifies 'to drive something away from oneself').

(116) x ODPĘDZA $y : \bigvee_{w}, z\ L(x, w) \wedge Ag(x, Ag(y, Trans(L(y, w), L(y, z)))) \wedge (x \in Anim) \wedge (y \in Anim)$.

[x DRIVES y off $: \bigvee_{w}, z\ L(x, w) \wedge Ag(x, Ag(y, Trans(L(y, w), L(y, z)))) \wedge (x \in Anim) \wedge (y \in Anim)$.]

(117) x ODPĘDZA y od $u : \bigvee_{w,z} L(u, w) \wedge Ag(x, Ag(y, Trans(L(y, w), L(y, z)))) \wedge (x \in Anim) \wedge (y \in Anim)$.

[x DRIVES y off $u : \bigvee_{w,z} L(u, w) \wedge Ag(x, Ag(y, Trans(L(y, w), L(y, z)))) \wedge (x \in Anim) \wedge (y \in Anim)$.]

The latter two formulas could possibly be simplified to:

(118) x ODPĘDZA (od siebie) $y : \bigvee_z Ag(x, Ag(y, Trans(L(y, x), L(y, z)))) \wedge (x \in Anim) \wedge (y \in Anim)$.

[x DRIVES y (away from oneself) : $\bigvee_z Ag(x, Ag(y, Trans(L(y, x), L(y, z)))) \wedge (x \in Anim) \wedge (y \in Anim)$.]

(119) x ODPĘDZA y od $u : \bigvee_w : Ag(x, Ag(y, Trans(L(y, u), L(y, w)))) \wedge (x \in Anim) \wedge (y \in Anim)$.

[x DRIVES y off $u : \bigvee_w : Ag(x, Ag(y, Trans(L(y, u), L(y, w)))) \wedge (x \in Anim) \wedge (y \in Anim)$.]

In the English language the 'starting point' may be specified with other means; the best equivalent for *odpędzać* is 'to drive off', which is based on different grammatical mechanisms, but very close with regard to meaning.

The verb *jechać* presents a different set of problems. It signifies transportation on the back of an animal or by means of a vehicle — and does not have a direct equivalent e.g. in the English language. In its basic meaning, *jechać* is associated with travelling by land, but its reduced meaning does not entail such a limitation, especially if it appears with prefixation — *pojechać*, *wyjechać*, *przjechać*. In such cases it may also signify flying by plane or travelling by boat.

The interpretation of *jechać* is made even more complicated by the fact that (contrarily to English verbs, which are more specialised in their meaning) it may describe many different situations. It may be used to signify travelling with or without being in control of the means of transport (the English equivalents for the former case are: 'to drive' and 'to ride'). What is more, in the latter case the object may not be aware of being transported (e.g. if the sentence pertains to goods or infants) or travel of their own volition (at least in the direct sense; indirectly, a person may travel e.g. as a result of their employer's request). In the Polish language the mentioned differences are not reflected in the structure of the sentence — as the same verb *jechać* is used for all cases — the present analysis will provide varying interpretations of the verb to mirror the semantic differences of other languages.

(120) x JEDZIE^{1a} : $\bigvee_u \bigvee_i \bigvee_y \bigvee_{w,z} Ag(u, R^1_i(x, y)) \wedge T(Trans(L(x, w), L(x, z)), Trans(L(y, w), L(y, z))) \wedge ((y \in Anim_{transport}) \vee (y \in Vehicle))$,

[x IS TRANSPORTED: $\bigvee_u \bigvee_i \bigvee_y \bigvee_{w,z} Ag(u, R^1_i(x, y)) \wedge T(Trans(L(x, w), L(x, z)), Trans(L(y, w), L(y, z))) \wedge ((y \in Anim_{transport}) \vee (y \in Vehicle))$,]

where $R^1{}_i$ represents the specific relation of being transported, the categorisations of y are obvious in the light of the above discussion, and the second element of the conjugation in the *definiens* specifies that the

movement of x is simultaneous with the movement of y and proceeds from the same point in space to the same location.

(121) x JEDZIE^{1b} : $\bigvee_i \bigvee_y \bigvee_{w,z} z\ Ag(x, R_i^1(x, y)) \wedge T(Trans(L(x, w), L(x, z)), Trans(L(y, w), L(y, z))) \wedge ((y \in Anim_{transport}) \vee (y \in Vehicle))$,

[x IS TRANSPORTED OF THEIR OWN VOLITION: $\bigvee_i \bigvee_y \bigvee_{w,z} Ag(x, R_i^1(x, y)) \wedge T(Trans(L(x, w), L(x, z)), Trans(L(y, w), L(y, z))) \wedge ((y \in Anim_{transport}) \vee (y \in Vehicle))$,]

The difference between (120) and (121) consists in the fact that in the latter case x is the agent in the first part of the conjugation in the *definiens*, which makes the introduction of the bound variable u redundant.

(122) x JEDZIE^2 : $\bigvee_i \bigvee_y \bigvee_{w,z} Ag(x, R_i^1(x, y)) \wedge Ag(x, Trans(L(y, w), L(y, z)) \wedge T(Trans(L(x, w), L(x, z)), Trans(L(y, w), L(y, z))) \wedge ((y \in Anim_{transport}) \vee (y \in Vehicle))$.

[x DRIVES/RIDES : $\bigvee_i \bigvee_y \bigvee_{w,z} Ag(x, R_i^1(x, y)) \wedge Ag(x, Trans(L(y, w), L(y, z)) \wedge T(Trans(L(x, w), L(x, z)), Trans(L(y, w), L(y, z))) \wedge ((y \in Anim_{transport}) \vee (y \in Vehicle))$].

This formula has an additional element in its conjunction (the second part), which specifies that x is causing the movement of y.

As regards the relation $R_i^1(x, y)$ appearing in formulas (120) — (122), an additional stipulation may be introduced, specifying that:

(123) $R_i^1(x, y) \rightarrow L(x, y)$,

yet this does not appear necessary; in future studies the relation appearing in the above formulas may probably be introduced as a constant.

The verbs *płynąć* and *lecieć* also have varied meanings. The cases when the verbs signify 'to go by boat' and 'to go by air' and pertain to objects transported by or in control of the respective modes of transport, require a different categorisation of y and the introduction of the predicate P_j, which specifies the state of y (which may be located in a gaseous or a liquid environment, or in outer space). When the verbs *płynąć* and *lecieć* pertain to creatures that are flying or swimming (e.g. fish, birds, insects), their interpretation needs to include the appropriate categorisation of x, an indication that the movement is auto-agentive (cf. the first element of the conjunction in (113)) and the appropriate indication of the state of x (being in water or in air). The formal notation of these verbs is not presented in the analysis, as it can be easily extrapolated.

Verbs such as *opadać*, *wznosić się* etc. ('to descend' and 'to ascend' respectively, in the motional sense) can be interpreted in two differing ways:

agentive and non-agentive. The corresponding formulas would be as follows:

(124) x OPADA^1 : $\bigvee_i \bigvee_y \bigvee_z Ag(x,\ Trans(L(x,\ y),\ L(x,\ z))) \wedge R_i^1(x,\ \mathrm{z})$;

[x DESCENDS^1 : $\bigvee_i \bigvee_y \bigvee_z Ag(x,\ Trans(L(x,\ y),\ L(x,\ z))) \wedge R_i^1(x,\ \mathrm{z})$];

(125) x OPADA^2 : $\bigvee_i \bigvee_y \bigvee_z Trans(L(x,\ y),\ L(x,\ z)) \wedge R_i^1(y,\ \mathrm{z})$;

[x DESCENDS^2 : $\bigvee_i \bigvee_y \bigvee_z Trans(L(x,\ y),\ L(x,\ z)) \wedge R_i^1(y,\ \mathrm{z})$].

The verb *opadać* is slightly more problematic in its semi-metaphorical uses, e.g. in the sentence *droga opada* (the road descends). The verb is not used figuratively, like in such sentences as *zapał opada* (enthusiasm diminishes), because the object is physical, yet expressions such as *droga opada* are rather imprecise. The suggested formal representation is as follows:

(126) x OPADA^3 : $\bigvee_{x_1,x_2 \subset^0 x} \bigvee_i \bigvee_{y,z} L(x_1,\ y) \wedge L(x_2,\ z) \wedge R_i^1(y,\ \mathrm{z}) \wedge (x \in$ *Linear*).

[x DESCENDS^3 : $\bigvee_{x_1,x_2 \subset^0 x} \bigvee_i \bigvee_{y,z}, L(x_1,\ y) \wedge L(x_2,\ z) \wedge R_i^1(y,\ \mathrm{z}) \wedge (x \in$ *Linear*)].

Interpretation: there exist certain sections of a road (a linear object) located at different points in space and a specific relation exists between the said sections. In the case of (124) — (126) R_i^1represents the relation of being located higher. In the case of the verb *wznosić się* (to ascend), the notation will be analogous, but R_i^1 will stand for the opposite type of relation (i.e. being located lower). It appears that the verb *spadać* (to fall) may only be interpreted in a non-agentive manner, i.e. using formula (125).

Other verbs signifying movement greatly differ in interpretation, owing to the many dissimilarities between them. Such verbs often require adding a specific (often very complex) location — the apparatus used in the present analysis should suffice to represent them in formal notation. In many cases analysis would require the interpretation of not only the verb itself, but also of the locative components.

The group of verbs signifying the movement of a liquid may also be described relatively easily, by introducing a proper categorisation such as $x \in$ *Liquid*. Some problems may arise in connection with colloquial semi-metaphorical uses such as *rzeka płynie* (the river flows), as, technically speaking, it is not the river that flows, but the water in it. However, even such problems may be overcome using the apparatus of the present work (a similar — though not entirely equivalent — problematic issue was discussed in connection with (126)).

Verbs indicating the transition from one state to another, such as

blednąć, *blednieć* (both meaning: to pale), *zielenieć* (to become green), *czerwienieć* (to redden), *stygnąć* (to cool down), *topnieć* (to melt), *rosnąć* (to grow), *kurczyć się* (to shrink), etc., not understood as a transition from a standard to a non-standard state (cf. *gnić*, *pleśnieć*, *płowieć*, etc.), may be divided into two categories. The first one includes verbs that indicate a new state without providing information on the previous state (e.g. *czerwienieć*, *zielenieć*). Such verbs may be interpreted as follows:

(127) x ZIELENIEJE : $\bigvee_i Trans(\neg\ P_i(x),\ P_i(x)) \wedge (i \in\ Colour)$,

[x BECOMES GREEN : $\bigvee_i Trans(\neg\ P_i(x),\ P_i(x)) \wedge (i \in\ Colour)$,]

where i represents the state and is appropriately categorised.

The latter category contains verbs that give some indication of the previous state as well as the new one and specify the relation between the two states. These can be interpreted as:

(128) x STYGNIE : $\bigvee_{i,j} \bigvee_{z,z'} Trans(P_i(x),\ P_j(x)) \wedge M(s,\ P_i(x),\ z) \wedge M(s,\ P_j(x),\ z') \wedge (z < z') \wedge (z,\ z' \in\ Temp)$.

[x COOLS DOWN : $\bigvee_{i,j} \bigvee_{z,z'} Trans(P_i(x),\ P_j(x)) \wedge M(s,\ P_i(x),\ z) \wedge M(s,\ P_j(x),\ z') \wedge (z < z') \wedge (z,\ z' \in\ Temp)$].

Interpretation: x undergoes a transition from a specific state to another, and the specified measure (in this case: temperature) of the new state is lower than that of the previous state. The verb *rosnąć* (meaning: 'to grow', 'to become larger') could be represented using a very similar formula, in which the measure of the previous state would be smaller than that of the new state, and the measure would be categorised differently (as e.g. *height*, *size*, etc.).

The verb *topnieć* (to melt) is a separate case. It resembles the latter category, but signifies a change in the state of matter; it is also the case with *zamarzać* (to freeze) and *parować* (to evaporate; the other meaning of the verb *parować* — to steam-boil — shall not be discussed in the present analysis). The change in the state of matter is, of course, related to the change in temperature, yet this fact is not explicitly conveyed by the verbs (it belongs to our extra-linguistic knowledge). Such verbs may be represented using the following general formula:

(129) $\bigvee_{i,j} Trans(P_i(x),\ P_j(x)) \wedge (i, j \in\ State)$,

Where *State* stands for the general category of the state of matter; for each verb the category may be specified further, e.g. as *Solid*, *Liquid*, *Gas*, etc.).

Very rarely verbs may also refer to the subjective feeling of transition

from one state to another; the feeling may or may not be rooted in a factual transition — the verb itself gives no indication thereof. Presumably, such verbs may only belong to the latter of the two groups discussed above. The category may be exemplified by the verb *marznąć* (to become cold):

(130) x MARZNIE : $\bigvee_{i,j} \bigvee_{z,z'}$ $Exp(x,\ Trans(P_i(x),\ P_j(x))) \wedge M(x,\ P_i(x),\ z) \wedge M(x,\ P_j(x),\ z') \wedge Exp(x,\ z' < z)) \wedge (z,\ z' \in\ Temp)$.

The same verb may also be interpreted as: x feels that they are cold. In this case the correct formula would be:

(131) x MARZNIE : $\bigvee_{i} \bigvee_{z}$ $Exp(x,\ P_i(x)) \wedge M(x,\ P_i(x),\ z) \wedge Exp(x,\ small(z)) \wedge (z \in\ Temp)$.

It is now time to discuss the issues related to describing the most problematic group of verbs, namely the ones referring to psychological states and modality.

Some similarities may be found between such verbs and the already discussed verbs related to experiencing. Let us reiterate the statement that to indicate that x is experiencing certain sensations consciously, the following formula may be used:

(132) x *świadomie* V_{sens}(że) y : $Exp(x,\ Exp(x,\ y))$.

[x *consciously* V_{sens}(that) y : $Exp(x,\ Exp(x,\ y))$].

However, the above formula will not be used throughout the present analysis, because on the linguistic level the verbs signifying the experiencing of emotional states do not explicitly state whether the sensation is experienced consciously, subconsciously or involuntarily.

Verbs designating emotional states may be represented by one of the two general formulas:

(133) $x\ V_{+em}\ y : \bigvee_{z}\ V(x,\ R^1_2(x,\ y) \vee R^1_3(x,\ y) \vee R^1_4(x,\ y),\ z) \wedge (z > 0)$;

(134) $x\ V_{-em}\ y : \bigvee_{z}\ V(x,\ R^1_2(x,\ y) \vee R^1_3(x,\ y) \vee R^1_4(x,\ y),\ z) \wedge (z < 0)$.

The only difference between these two is that (133) pertains to positive emotional states (i.e. ones evaluated positively by the person experiencing them), whereas (134) refers to negative emotional states. The difference is indicated by the use of '+' and '-' signs in the subscripts (in the *definiendum*) and the specification that z is either less than or more than zero (in the *definiens*).

Each emotional state is considered from the point of view of the person experiencing it — i.e. from the perspective of x. The relations corresponding to such states and delineated by specific verbs may be symmetrical — which

is dependent on the second argument, namely y. In some categories symmetry can never occur — irrespective of whether the verb designates an emotional state or a sensation; cf. *Jan widzi dom* (Jan sees a house), *Jan lubi grochówkę* (Jan likes bean soup). In other cases the relation may be symmetrical: *Jan widzi Marię* (Jan sees Maria), *Jan lubi Marię* (Jan likes Maria); yet symmetry is never assumed necessary. Moreover, the symmetry of relations is rarely (if at all) conveyed by the verb itself. For this reason, the formal notation invariably presents the verbs through the prism of x.

The idea behind such an interpretation is that x may ascribe a positive or a negative value to their contacts with y; the contact may be physical/sensual, notional, or social. Examples of the first category include e.g. liking some kind of food or some fabric used for clothing or decoration; the second category is exemplified by sentences referring to feelings towards imaginary characters, e.g. from a book; the third type of contact is described in sentences referring to feelings towards specific people. It must be noted that the value is connected to x's personal attitude towards a given object/person. This reservation is particularly significant in the case of the third type of contact: we may esteem a person, but dislike them (or *vice versa*). In such a case we would ascribe a positive value to the character features of a given person, but not to our personal contacts with this person.

(135) x CENI $y : \bigvee_i \bigvee_z V(x, P_i(y), z) \wedge (z > 0) \wedge (i \in Eth \cup Int \cup Prof \cup Econ)$.

[x ESTEEMS $y : \bigvee_i \bigvee_z V(x, P_i(y), z) \wedge (z > 0) \wedge (i \in Eth \cup Int \cup Prof \cup Econ)$].

Interpretation: x ascribes a positive value to a certain feature (state) of y, and the features (states) in question are ethical, intellectual, professional or economical in nature.

The details of this interpretation may be altered in the course of future studies. One issue worth considering is whether social contact does not always imply some sort of physical contact (it may be so). Reducing purely notional contact to the realm of the senses would be more difficult, but even this could be achieved with the help of some theoretical assumptions. The categorisation of the subscript i included in the above formula shall perhaps be altered as well.

Cases where reciprocity is explicitly stated could be represented as:

(136) x i y V_{+em}*wzajemnie* : $\bigvee_{w,z}, V(x, R^1_4(x, y), w) \wedge V(y, R^1_4(y, x), z) \wedge (w > 0) \wedge (z > 0)$.

[x and y V_{+em}*reciprocally* : $\bigvee_{w,z}$, $V(x, R_4^1(x, y), w) \wedge V(y, R_4^1(y, x), z) \wedge (w > 0) \wedge (z > 0)$].

In this case the choice is limited to social contacts, since the definition of the relation R_4^1 allows for symmetry (it is a matter of the assumed convention, which practically eliminates the possibility for symmetry in the case of the relation R_2^1 interpreted narrowly as sensual contact experienced by one side only). As noted above, the accuracy of the formal measures adopted in the analysis is a matter for discussion. In the Polish language such cases are expressed with a reflexive form of the verb such as *Jan i Maria lubią się* — there is no need to add the adverb *wzajemnie* (meaning: 'reciprocally'); in the English language more explicit forms such as *John and Mary like each other* are used. Verbs conveying negative emotional value could be represented using a formula very similar to (136), in which the values of w and z would be specified as less than zero. If both w and z are either greater or less than zero, comparing the two values does not seem necessary, since the verbs in the category under analysis do not imply that the emotional state experienced by both parties is of equal intensity.

Verbs expressing opinions in a general fashion, e.g. *sądzić, że...* (to suppose that), *przypuszczać, że...* (to assume that), *myśleć, że...* (to think that), etc. may be represented using the following basic formula (the verb *myśleć* signifying 'to muse' in sentences that do not specify the subject of consideration, e.g. *Jan myśli*, will be discussed below):

(137) x SĄDZI (że) y: $B(x, y)$,
[x SUPPOSES (that) y: $B(x, y)$].

The formula does not set any limitations regarding the time difference between the moment in which a given supposition is made and the time of the occurrence specified in y; it is understandable that opinions may pertain to occurrences that (allegedly) took place before the supposition was experienced, at the same time or even after. As we shall soon demonstrate, the statement is not true for all verbs.

(138) x WIE, że $y : \bigvee_{t,t'}$, $B_t(x, y_{t'}) \wedge y_{t'} \wedge (t' \leqslant t)$.
[x KNOWS that $y : \bigvee_{t,t'}$, $B_t(x, y_{t'}) \wedge y_{t'} \wedge (t' \leqslant t)$].

The present analysis focuses on a rather strong understanding of the verb *wiedzieć, że...* (to know that), which is consistent with the intuitive perception of the verb (even though one may sometimes encounter weaker definitions which do not entail the veracity of the subject of knowledge). Thus, it must be assumed that a person's knowledge cannot pertain to subsequent occurrences. Such events can be predicted with a very high

degree of probability; they can be conjectured, but not known about (the only exception, discussed below, is virtual rather than factual). This is the reason for introducing a temporal reservation as the final element of the conjunction in the *definiens* of (138).

The mentioned exception pertains to expressions such as *Kowalski wie, że jutro jest sobota* (Kowalski knows that tomorrow is Saturday), *Kowalski wie, że pojutrze będzie zaćmienie słońca* (Kowalski knows that a solar eclipse will occur the day after tomorrow), etc. If such statements are true, i.e. if on Friday Kowalski is aware that the next day will be Saturday, or if Kowalski has been informed that a specific astronomical phenomenon will occur in two days, the sentences may indeed appear to be exceptions from the rule specified in (138). The exceptions are only virtual, since Kowalski's knowledge stems from previously acquired familiarity with certain conventions (the calendar in the first example) or laws of nature (as in the second example). Thus, such situations may be represented in the form of the following principle:

(139) $(B_t(x,\ y_{t'})\ y_{t'} \wedge (t' > t)) \rightarrow \bigvee\limits_{t'' \leqslant t} \bigvee\limits_{z} (B_t(x,\ z_{t''}) \wedge z_{t''} \wedge B_t(x,\ z_{t''} \rightarrow y_{t'}) \wedge (z_{t''} \rightarrow\ y_{t'}))$.

Interpretation: If x knows that a certain future event will occur, then x knows that this future occurrence results from another occurrence which is not subsequent to the time when x knows about the future occurrence.

Since formula (139) contains the expression that could be abbreviated to 'knows that' (it appears twice to the right side of the main implication symbol), the antecedent of the implication can be abbreviated to:

(140) $\bigvee\limits_{t'' \leqslant t} \bigvee\limits_{z} (know^1{}_t(x,\ z_{t''}) \wedge z_{t''} \wedge know^1{}_t\ (x,\ z_{t''} \rightarrow\ y_{t'}) \wedge (z_{t''} \rightarrow\ y_{t'}))$.

The same — somewhat intuitive — method will be used further on to shorten the formal notation which may prove too lengthy and, as a result, difficult to read. Moreover, it shall be assumed that $know^1$ represents 'to know that...', whereas $know^2$ stands for 'to know whether' (see: below).

(141) x MYLI SIĘ (sądząc) że y: $\bigvee\limits_{t,t'} B_t(x,\ y_{t'}) \wedge \neg\ y_{t'} \wedge (t' \leqslant\ t)$.

[x IS WRONG (in supposing) that y: $\bigvee\limits_{t,t'} B_t(x,\ y_{t'}) \wedge \neg\ y_{t'} \wedge (t' \leqslant\ t)$].

The conditions for relative chronology are the same as in the case of (138).

(142) x NIE WIE, że $y : \bigvee\limits_{t,t'} \neg\ B_t(x,\ y_{t'}) \wedge\ y_{t'} \wedge (t' \leqslant\ t)$.

[x DOES NOT KNOW that $y : \bigvee\limits_{t,t'} \neg\ B_t(x,\ y_{t'}) \wedge\ y_{t'} \wedge (t' \leqslant\ t)$.]

As seen from the above formula, *nie wiedzieć, że...* (to not know that...) is simply the negation of *wiedzieć, że...*; comparing the *definiens* of (138)

and (142) we see that only the first element of the conjunction is negated. The formula is thus consistent with the general assumptions of the present work: both *Kowalski wie, że jego żona jest chora* (Kowalski knows that his wife is ill) and *Kowalski nie wie, że jego żona jest chora* (Kowalski does not know that his wife is ill) implies that Kowalski's wife is not well. This fact is reflected in (138) and (142), as in both cases $y_{t'}$is presented as a true statement. This differentiates the two formulas from (141), in which only $y_{t'}$is negated (i.e. $y_{t'}$is interpreted as false).

(143) x WIE czy $y : \bigvee\limits_{t,t'} ((B_t(x,\, y_{t'}) \wedge y_{t'}) \vee (B_t(x,\, \neg\, y_{t'}) \wedge \neg\, y_{t'})) \wedge (t' \leqslant t)$.

[x KNOWS whether $y : \bigvee\limits_{t,t'} ((B_t(x,\, y_{t'}) \wedge y_{t'}) \vee (B_t(x,\, \neg\, y_{t'}) \wedge \neg\, y_{t'})) \wedge (t' \leqslant t)$].

Interpretation: x knows that $y_{t'}$or x knows that $\neg\, y_{t'}$. The formula lacks information regarding the actual situation: it is not known whether it is $y_{t'}$or $\neg\, y_{t'}$that is true.

(144) x NIE WIE, czy $y : \bigvee\limits_{t,t'} \neg\, B_t(x,\, y_{t'}) \wedge \neg\, B_t(x,\, \neg\, y_{t'}) \wedge (t' \leqslant t)$.

[x DOES NOT KNOW whether $y : \bigvee\limits_{t,t'} \neg\, B_t(x,\, y_{t'}) \wedge \neg\, B_t(x,\, \neg y_{t'}) \wedge (t' \leqslant t)$.]

There are two issues which must be discussed in connection with the above formulas. The first of them is related to the difference between *wiedzieć, że...* (to know that) and *wiedzieć, czy...* (to know whether). The formal notations for these expressions seem much more dissimilar than the phrases suggest. The expression 'x knows whether y' signifies: 'x knows that y or x knows that $\neg\, y$', whereas 'x does not know whether y' means: 'x does not presume that y and x does not presume that $\neg\, y$'. None of these expressions indicate what the factual situation might be. Secondly, it must be noted that 'x does not know whether y' goes beyond a simple negation of (143), just as (142) is not a simple negation of (138). A reference to (133) and (134) demonstrates that 'x does not like y' is not a mere negation of 'x likes y': the first of the two expressions is represented by formula (134), the second — by formula (133). The only difference between (133) and (134) appears in the last element of the conjunction (the value of z is either positive or negative).

The verb *informować* (to inform) and all other verbs that signify the conveying of information (by a human being or an information device) may be represented simply as:

(145) x INFORMUJE, że $y : S(x,\, y)$,

[x INFORMS that $y : S(x, y)$].

The recipient of the information is entirely insignificant, as is the matter of the veracity of the information conveyed and the temporal relation between the moment of informing and the time to which the piece of data pertains. In the case of information devices that are not associated with having any beliefs, more specific formulas are as follows:

(146) x TRAFNIE INFORMUJE, że $y : \bigvee\limits_{t,t'} S_t(x, y_{t'}) \wedge y_{t'} \wedge (t' \leqslant t)$;

[x ACCURATELY INFORMS that $y : \bigvee\limits_{t,t'}, S_t(x, y_{t'}) \wedge y_{t'} \wedge (t' \leqslant t)$];

(147) x MYLNIE INFORMUJE, że $y : \bigvee\limits_{t,t'}, S_t(x, y_{t'}) \wedge \neg\, y_{t'} \wedge (t' \leqslant t)$.

[x ERRONEOUSLY INFORMS that $y : \bigvee\limits_{t,t'}, S_t(x, y_{t'}) \wedge \neg\, y_{t'} \wedge (t' \leqslant t)$].

X is not categorised as an information device, since the same expressions could pertain to human beings, if the utterance focuses on the accuracy or inaccuracy of the statement, and not on the issue of intentions.

In the opposite case the formulas are as follows:

(148) x w dobrej wierze INFORMUJE, że $y : S(x, y) \wedge B(x, y)$;

[x in good faith INFORMS that $y : S(x, y) \wedge B(x, y)$];

(149) x w złej wierze INFORMUJE, że $y : S(x, y) \wedge B(x, \neg\, y)$.

[x in bad faith INFORMS that $y : S(x, y) \wedge B(x, \neg\, y)$].

In these two cases it is the issue of veracity that is disregarded, as the message focuses on the speaker's intentions.

By combining the two approaches and taking both the veracity and the speaker's intention into account, we arrive at four possible situations, presented — for the time being — only as the notation for the right side of the formula (the *definiens*):

(150) $\bigvee\limits_{t,t'} (t' \leqslant t) \wedge S_t(x, y_{t'}) \wedge B_t(x, y_{t'}) \wedge y_{t'}$;

(151) $\bigvee\limits_{t,t'} (t' \leqslant t) \wedge S_t(x, y_{t'}) \wedge B_t(x, y_{t'}) \wedge \neg\, y_{t'}$;

(152) $\bigvee\limits_{t,t'} (t' \leqslant t) \wedge S_t(x, y_{t'}) \wedge B_t(x, \neg\, y_{t'}) \wedge y_{t'}$;

(153) $\bigvee\limits_{t,t'} (t' \leqslant t) \wedge S_t(x, y_{t'}) \wedge B_t(x, \neg\, y_{t'}) \wedge \neg\, y_{t'}$;

If we disregard the order of the elements — which is of no consequence given the commutative property of conjunctions — formula (150) may be interpreted as: 'x knows that y and x informs that y'; (151) is equivalent to: 'x in good faith erroneously informs that y'; (152) represents: 'x knows that $\neg\, y$ and in bad faith informs that y'. Formula (153) conveys the most complicated message: 'x accurately informs that y, but acts in bad faith, as

x is convinced that $\neg\ y$'. It appears that all cases of conveying information in bad faith may be considered as lying, thus:

(154) x KŁAMIE, że $y : S(x,\ y) \wedge B(x, \neg\ y)$,
[x LIES that $y : S(x,\ y) \wedge B(x, \neg\ y)$],

would not be dependent on the veracity of the piece of information. The formula would also apply to cases in which the piece of information pertains to future events, which cannot be measured in terms of veracity. The general formula for '*x kłamie*' (x is lying) would be:

(155) x KŁAMIE : $\bigvee\limits_{y} S(x,\ y) \wedge B(x, \neg\ y)$,
[x LIES : $\bigvee\limits_{y}\ S(x,\ y) \wedge B(x, \neg\ y)$].

We shall, for the time being, disregard the issue of how the information was understood. It will be discussed in a later section of the present article, yet it does not seem significant for the analysis of the verb *kłamać* (to lie), if we assume that the verb indicates a discrepancy between the content of the message and the beliefs of the speaker. What seems more problematic is the source of the knowledge that x informs that y while being convinced that $\neg\ y$; all information on the beliefs and convictions of other people is indirect by nature and based on more or less justified suppositions. Thus, the situation described in (155) would pertain e.g. to the events of a novel, if we assume the convention of the author's omniscience (with regard to the work). In factual (and not notional) cases the more appropriate formula would be:

(156) x KŁAMIE : $\bigvee\limits_{y} S(x,\ y) \wedge B(s,B(\ x, \neg\ y))$.
[x LIES : $\bigvee\limits_{y} S(x,\ y) \wedge B(s,B(\ x, \neg\ y))$.]

Interpretation: x informs that y and the speaker is convinced that x is convinced that $\neg\ y$.

The verb *udawać, że...* (to pretend that...; not in the sense of play-pretending or acting) conveys a similar meaning, yet there seems to be a fundamental difference between *udawać* and *kłamać*. It does not consist in the fact that pretending is more related to non-verbal behaviour, as such actions may, in certain contexts, have a significant informative value (and, as noted above, the functor S does not pertain solely to verbal communication; for this reason the medium for conveying information is not categorised in the formulas presented, at least for the time being). The most important difference is that pretending always pertains to matters in some way related to the person pretending. Thus, the verb may be represented as:

(157) x udaje, że $y : (y = y(x)) \wedge S(x,\ y) \wedge B(s,\ B(x, \neg\ y))$.

[x is pretending that $y : (y = y(x)) \wedge S(x, y) \wedge B(s, B(x, \neg y))$.]

It must be emphasised that in this case veracity is of no importance: a person may pretend to be ill and be convinced that they are well, while in fact being ill and not knowing about it. (For more on *kłamać* and *udawać* see below).

The verb *grać* (to act; in the theatrical sense) is seemingly similar in meaning to *udawać*, yet a more detailed semantic analysis demonstrates, that the resemblance is very superficial. The matter shall be discussed in a later section of the work.

The verb *myśleć* (to think) poses many difficulties, mostly due to the fact that it is rather elusive to define, especially in the sense of 'consciously experiencing certain cerebral processes' rather than 'having an opinion' (i.e. thinking that...). If we interpret thinking as conveying a message to oneself and receiving it, the verb *myśleć* may be represented as:

(158) x MYŚLI : $\bigvee_y Exp(x, (S(x, y) \wedge Exp(x, y)))$.

[x THINKS : $\bigvee_y Exp(x, (S(x, y) \wedge Exp(x, y)))$].

The verb *rozumieć* (to understand) has several basic meanings and uses, which differ from the semantic point of view: *rozumieć*^{1}(to understand the content of semantic information), *rozumieć*^{2}(to understand a given language), *rozumieć*^{3}(to understand a problem), *rozumieć*^{4}(to understand the motives of someone's behaviour). This is not to mean that these four types represent the entire scope of the meaning of the verb *rozumieć*; yet only these types shall be analysed in the present study. The interpretations are as follows (as mentioned, the formulas make use of the previously presented definitions of other verbs, in this case the verb *wiedzieć* — to know):

(159) x ROZUMIE^1 (że) y : $\bigvee_z \bigvee_w S(z, y) \wedge R_1^3(w, y) \wedge R_2^1(x, w) \wedge know^1(x, R_1^3(w, y))$.

[x UNDERSTANDS^1 (that) y : $\bigvee_z \bigvee_w S(z, y) \wedge R_1^3(w, y) \wedge R_2^1(x, w) \wedge know^1(x, R_1^3(w, y))$.]

Interpretation: a person is sending a piece of information y through the medium of w, while x receives it and knows that it is the carrier of information y.

(169) x ROZUMIE^2 (język) L_i : $\bigvee_z \bigvee_y \bigvee_w S(z, y) \wedge R_1^3(w, y) \wedge (w \in L_i) \rightarrow (R_2^1(x, w) \wedge know^1(x, R_1^3(w, y)))$.

[x UNDERSTANDS^2 (language) L_i : $\bigvee_z \bigvee_y \bigvee_w S(z, y) \wedge R_1^3(w, y) \wedge (w \in L_i) \rightarrow (R_2^1(x, w) \wedge know^1(x, R_1^3(w, y)))$.]

Interpretation: if a person is sending a piece of information y through the medium of w belonging to language (the system of symbols in the code) $L_i$then if x perceives w then x knows that it is the carrier of information y.

(161) x ROZUMIE^3 (dlaczego) $y : \bigvee_z know^1(x, z) \wedge know^1(x, z \rightarrow y)$.

[x UNDERSTANDS^3 (why) $y : \bigvee_z know^1(x, z) \wedge know^1(x, z \rightarrow y)$].

(162) x ROZUMIE^4 (dlaczego) $y : \bigvee_z know^1(x, z) \wedge B(x, z \rightarrow y)$.

[x UNDERSTANDS^4 (why) $y : \bigvee_z know^1(x, z) \wedge B(x, z \rightarrow y)$].

Both cases refer to explaining a certain phenomenon; the difference is demonstrated by the second element of the conjunction: it seems that in the case of understanding motives for somebody's behaviour it is more accurate to treat this as a belief and not as knowledge.

The verb *rozumieć*^{2} may also be used in a different context, namely one in which x is not a human being but an automaton or an animal that reacts to a command. The symbolic interpretation presented in the *definiens* of (160) cannot be applied to such cases, since x is not likely to have any beliefs (as *know* would imply). Moreover, y needs to be limited to belonging to the set of instructions for x. The formula presented below may raise doubts, but appears acceptable, if the theoretical apparatus of the present work is adhered to.

(163) x ROZUMIE$^{2'}$ $y : \bigvee_{z\ y\ w\ i\ j}(S(z, y) \wedge (y \in P_j(x)) \wedge R_1^3(w, y) \wedge (w \in L_i)) \rightarrow (R_2^1(x, w) \wedge Ag(x, y))$.

[x UNDERSTANDS$^{2'}$ $y : \bigvee_{z\ y\ w\ i\ j}(S(z, y) \wedge (y \in P_j(x)) \wedge R_1^3(w, y) \wedge (w \in L_i)) \rightarrow (R_2^1(x, w) \wedge Ag(x, y))$].

Additional limitations (which were not introduced in (160) are placed on y — the information needs to pertain to a certain state of x; when x perceives the carrier of this piece of information (or receives a signal) it acts so that it is in the state delineated by y, i.e. behaves as instructed.

The concept of understanding is closely related to that of communication. In the present work, the corresponding situations are illustrated in a slightly different manner. It might be assumed that the verb *rozumieć* has yet another basic meaning: *rozumieć*^{5}*kogoś* (to understand someone) — to understand the piece of information sent that someone. The nuances of meaning are reflected in the surface structure: in the case of 'x *rozumie*^{5} y', what needs to stand for y is a name (of the sender of the information) and not a sentence (the message conveyed). For maximum clarity, the *definiendum* in the four formulas presented below appears in the passive voice, in order to distinguish these cases from the previously discussed meanings.

(164) x JEST ROZUMIANY przez y : $\bigvee\limits_{z}\bigvee\limits_{w} S(x, z) \wedge R_1^3(w, z) \wedge R_2^1(y, w) \wedge know^1(y, R_1^3(w, z)))$.

[x IS UNDERSTOOD by y : $\bigvee\limits_{z}\bigvee\limits_{w} S(x, z) \wedge R_1^3(w, z) \wedge R_2^1(y, w) \wedge know^1(y, R_1^3(w, z)))$].

The differences between this formula and (159) are limited to the dissimilar categorisation of the variables x, y, z

(165) x NIE JEST ROZUMIANY przez y : $\bigvee\limits_{z}\bigvee\limits_{w} S(x, z) \wedge R_1^3(w, z) \wedge R_2^1(y, w) \wedge \neg\, know^1(y, R_1^3(w, z)))$.

[x IS NOT UNDERSTOOD by y : $\bigvee\limits_{z}\bigvee\limits_{w} S(x, z) \wedge R_1^3(w, z) \wedge R_2^1(y, w) \wedge \neg\, know^1(y, R_1^3(w, z)))$].

The only difference between the above formula and (164) consists in the negation of the final element of the conjunction in the *definiens*.

(166) x NIE JEST ROZUMIANY przez y z powodu zniekształcenia sygnału: $\bigvee\limits_{z}\bigvee\limits_{w,u} S(x, z) \wedge R_1^3(w, z) \wedge R_2^1(y, u) \wedge (u \neq w) \wedge \neg\, B(y, R_1^3(u, z)))$.

[x IS NOT UNDERSTOOD by y due to the signal being distorted: $\bigvee\limits_{z}\bigvee\limits_{w,u} S(x, z) \wedge R_1^3(w, z) \wedge R_2^1(y, u) \wedge (u \neq w) \wedge \neg\, B(y, R_1^3(u, z)))$].

(167) x JEST ROZUMIANY przez y pomimo zniekształcenia sygnału: $\bigvee\limits_{z}\bigvee\limits_{w,u} S(x, z) \wedge R_1^3(w, z) \wedge R_2^1(y, u) \wedge (u \neq w) \wedge B(y, R_1^3(u, z)))$.

[x IS UNDERSTOOD by y despite the signal being distorted: $\bigvee\limits_{z}\bigvee\limits_{w,u} S(x, z) \wedge R_1^3(w, z) \wedge R_2^1(y, u) \wedge (u \neq w) \wedge B(y, R_1^3(u, z)))$].

The final elements of the *definiens* in formulas (166) and (167) prove even more problematic: we cannot state that y knows that u is carrying information z (in (167)) or that y does not know that u is carrying information z (in (166)), since the definition of the verb 'to know' would imply that it is u that is the carrier of information z, while, in fact, in the moment when the information was generated, it was transmitted by the medium of w. Strictly speaking, u is not carrying the piece of information z (it may be carrying a different message, or not carrying any message at all). Formula (167) represents a case of error correction. The manner in which y arrives at the conclusion that u is a distorted carrier of information z is a problem that shall not be discussed in the present analysis.

The case described in (167) is similar to the circumstances indicated by the use of the verb *domyślać się* (to surmise):

(168) x DOMYŚLA SIĘ (że) y: $\bigvee\limits_{z} know^1(x, z) \wedge B(x, z \rightarrow y)$.

[x SURMISES (that) y: $\bigvee\limits_{z} know^1(x, z) \wedge B(x, z \rightarrow y)$].

This interpretation implies that y — which is the subject of the surmise — does not have to be true, i.e. that one may surmise erroneously. Nevertheless, the situation appears to change when a perfective form in the past tense is used: '*x domyślił się, że y*' signifies 'x guessed that y', which suggests that y is true.

This phrase may be represented as:

(169) x DOMYŚLIŁ SIĘ (że) y: $\bigvee_{z} \bigvee_{t_1,t_2,t_3,t_4} (t_1 < t_4) \wedge know^1{}_{t2}(x, z_{t2}) \wedge B_{t1}(x, z_{t2} \rightarrow y_{t3})\ know^1{}_{t4}(x, z_{t3})$.

[x GUESSED (that) y: $\bigvee_{z} \bigvee_{t_1,t_2,t_3,t_4} (t_1 < t_4) \wedge know^1{}_{t2}(x, z_{t2}) \wedge B_{t1}(x, z_{t2} \rightarrow y_{t3})\ know^1{}_{t4}(x, z_{t3})$].

The veracity of y_{t3} is implied by the final element of the conjunction constituting the *definiens*. The definition of $know^1$ entails that $t_2 \leqslant t_1$ and that $t_3 \leqslant t_4$, yet there is no general method for establishing the temporal relations between t_3 and $t_2$or t_2. Significantly, x could have guessed that y on the basis of z believing that z implies a previous occurrence of y or portends the future occurrence of y, etc.

(170) x INFORMUJe y, że z: $\bigvee_{w} S(x, z) \wedge R^3_1(w, z) \wedge Ag\ (x, R^1_2(y, w))$.

[x INFORMS y that z: $\bigvee_{w} S(x, z) \wedge R^3_1(w, z) \wedge Ag\ (x, R^1_2(y, w))$.]

Interpretation: x conveys the message z by means of z and acts so that z reaches y. This interpretation does not imply that y understands the message z.

(171) x OCENIA y : $\bigvee_{z} \bigvee_{i} V(x, P_i(y), z)$.

[x EVALUATES y :$\bigvee_{z} \bigvee_{i} V(x, P_i(y), z)$].

The interpretation of the above formula stems directly from the role of the functor V. If y designates an occurrence and not an object, i.e. is a sentence and not a name, then the formula should take the following form:

(172) x OCENIA y : $\bigvee_{z} V(x, y, z)$.

[x EVALUATES y : $\bigvee_{z} V(x, y, z)$].

(173) x NIE DOCENIA y: $\bigvee_{i} \bigvee_{w,z} V(x, P_i(y), w) \wedge V(s, P_i(y), z) \wedge B(s, (0 < w < z)) \wedge B(s, correct(z))$.

[x UNDERVALUES y: $\bigvee_{i} \bigvee_{w,z} V(x, P_i(y), w) \wedge V(s, P_i(y), z) \wedge B(s, (0 < w < z)) \wedge B(s, correct(z))$.]

The verb *nie doceniać* (to undervalue) appears to denote that the speaker believes that x evaluates y positively, but not high enough.

(174) x PRZECENIA $y : \bigvee_{i} \bigvee_{w,z} V(x, P_i(y), w) \wedge V(s, P_i(y), z) \wedge B(s, (w > z)) \wedge B(s, correct(z))$.

[x OVERVALUES $y : \bigvee_{i} \bigvee_{w,z} z\ V(x, P_i(y), w) \wedge V(s, P_i(y), z) \wedge B(s, (w > z)) \wedge B(s, correct(z))$].

In this case the evaluation does not seem to contain any reference to the zero point on the scale.

(175) x DOCENIA $y : \bigvee_{i} \bigvee_{w,z} V(x, P_i(y), z) \wedge (z > 0) \wedge B(s, correct(z))$.

Formulas (173) — (173) pertain mostly to situations in which one human being is evaluated by another. Utterances such as *Jan nie docenia ewentualnych konsekwencji tego faktu* (Jan underestimates the possible consequences of this fact) or *Jan przecenia znaczenie tego faktu* (Jan overestimates the importance of this fact) are much more difficult to interpret; but possibly easier than *Jan nie docenia grożącego mu niebezpieczeństwa* (Jan underestimates the danger he is in). The problem with interpretation is that such utterances do not simply imply the fact that Jan ascribes a certain value to a given phenomenon. In the case of underestimating danger, Jan may for example deem the unpleasant occurrence to be less probable than it is in the opinion of the speaker. In such a situation Jan ascribes a given measure to a certain probability (which the speaker considers to be too small). The sentence may also be understood as: Jan thinks that his actions will have certain consequences, whereas the speaker is convinced that these actions will have different consequences, ones that Jan (or the speaker, or both) will regard as worse. This example could be interpreted in terms of either values or measures. The above analysis emphasises the importance of context. Depending on the interpretation, the formula would be:

(176) x NIE DOCENIA (groźby) $y : \bigvee_{i,j,m,n} \bigvee_{z} V(x, y, z) \wedge (z < 0) \wedge B(x, Prob(y, [i, j])) \wedge B(s, Prob(y, [m, n])) \wedge (m \geqslant i) \wedge (n > j)$.

[x IS UNDERESTIMATING (the threat of) $y : \bigvee_{i,j,m,n} \bigvee_{z} V(x, y, z) \wedge (z < 0) \wedge B(x, Prob(y, [i, j])) \wedge B(s, Prob(y, [m, n])) \wedge (m \geqslant i) \wedge (n > j)$].

or

(177) x NIE DOCENIA (groźby) $y : \bigvee_{z_1,z_2} \bigvee_{w_1,w_2} B(x, y \rightarrow z_1) \wedge B(s, y \rightarrow z_2) \wedge V(x, z_1, w_1) \wedge V(s, z_2, w_2) \wedge (w_1 > w_2) \wedge (w_2 < 0)$.

[x IS UNDERESTIMATING (the threat of) $y : \bigvee_{z_1,z_2} \bigvee_{w_1,w_2} B(x, y \rightarrow z_1) \wedge B(s, y \rightarrow z_2) \wedge V(x, z_1, w_1) \wedge V(s, z_2, w_2) \wedge (w_1 > w_2) \wedge (w_2 < 0)$].

The above interpretations are merely examples; one may easily imagine a situation in which (176) and (177) would occur simultaneously: the

speaker would deem y more probable and more detrimental to x than in x's estimation.

(178) x BOI SIĘ (że) y : $\bigvee_{i,j} \bigvee_{z} B(x, Prob(y, [i, j])) \wedge B(x, (j > 0)) \wedge V(x, y, z) \wedge (z < 0)$.

[x IS AFRAID (that) y : $\bigvee_{i,j} \bigvee_{z} B(x, Prob(y, [i, j])) \wedge B(x, (j > 0)) \wedge V(x, y, z) \wedge (z < 0)$.]

Interpretation: x considers occurrence y to be possible and to be disadvantageous to x (i.e. valued negatively).

In many cases $y = y(x)$, which means that the occurrence y pertains to x personally. This is also true for such abbreviated expressions as *Kowalski boi się choroby* (Kowalski is afraid of illness), which is equivalent to: *Kowalski boi się, że zachoruje* (Kowalski is afraid that he will fall ill).

(179) x BOI SIĘ y: $\bigvee_{i,j} \bigvee_{z} B(x, Prob(R_2^1(x, y) \vee R_4^1(x, y)), [i, j]) \wedge B(x, (j < 0)) \wedge V(x, R_2^1(x, y) \vee R_4^1(x, y), z) \wedge (z < 0)$.

[x IS AFRAID of y: $\bigvee_{i,j} \bigvee_{z} B(x, Prob(R_2^1(x, y) \vee R_4^1(x, y)), [i, j]) \wedge B(x, (j < 0)) \wedge V(x, R_2^1(x, y) \vee R_4^1(x, y), z) \wedge (z < 0)$].

Interpretation: x considers their social or physical contact with y to be possible and to be disadvantageous to x (i.e. valued negatively).

Major problems with interpretation also appear in connection with the verb *dziwić się* (to be astonished). The present analysis pertains to cases when y is a sentence, as exemplified in the expressions *dziwić się, że...* (to be astonished that); thus, *dziwić się czemuś* (to be astonished at something) is considered equivalent to *dziwić się, że*. Firstly, the present study contains the assumption that *dziwić się, że...* (to be astonished that) implies *wiedzieć, że...* (to know that); secondly, it considers two different situations in which the expression may be used: (a) when initially x is not taking the possibility of y into account, and (b) when initially x considers y unlikely.

(180) x DZIWI SIĘ (że) y : $Exp(x, Trans(\neg B(x, y), know^1(x, y)))$.

[x IS ASTONISHED (that) y : $Exp(x, Trans(\neg B(x, y), know^1(x, y)))$].

(181) x DZIWI SIĘ (że) y : $\bigvee_{i,j} Exp(x, Trans(B(x, Prob(y, [i, j]) \wedge small(j)), know^1(x, y)))$.

[x IS ASTONISHED (that) y : $\bigvee_{i,j} Exp(x, Trans(B(x, Prob(y, [i, j]) \wedge small(j)), know^1(x, y)))$].

The above interpretations do not seem entirely satisfactory. Formula (180) is especially wanting, as the same interpretation could be used for the phrase x *dowiaduje się, że* y (x finds out that y). The only possible

counterargument against this allegation is the use of the functor *Exp*, yet even this defence is rather feeble. On the other hand, a more accurate notation would be difficult to devise; the formal interpretation of *dowiadywać się* (to find out that) ought to be more complex, as this verb indicates receiving a specific piece of information (contrarily to *przekonać się* — to become convinced). The following two examples are more convenient to analyse in their perfective forms:

(182) x DOWIEDZIAŁ SIĘ, że $y : \bigvee_z \bigvee_w S(z, y) \wedge R^3_1(w, y) \wedge R^1_2(x, w) \wedge Exp(x, Trans(\neg B(x, y), know^1(x, y)))$.

[x FOUND OUT that $y : \bigvee_z \bigvee_w S(z, y) \wedge R^3_1(w, y) \wedge R^1_2(x, w) \wedge Exp(x, Trans(\neg B(x, y), know^1(x, y)))$].

(183) x PRZEKONAŁ SIĘ, że $y : Exp(x, y) \wedge Exp(x, Trans(\neg B(x, y), know^1(x, y)))$.

[x BECAME CONVINCED that $y : Exp(x, y) \wedge Exp(x, Trans(\neg B(x, y), know^1(x, y)))$].

The verbs *pamiętać* (to remember) and *zapomnieć* (to forget) may be interpreted twofold:

(184) x PAMIĘTA, że $y : Trans(know^1(x, y), know^1(x, y))$.

[x REMEMBERS that $y : Trans(know^1(x, y), know^1(x, y))$].

(185) x PAMIĘTA, że $y : Exp(x, Trans(know^1(x, y), know^1(x, y)))$.

[x REMEMBERS that $y : Exp(x, Trans(know^1(x, y), know^1(x, y)))$].

(186) x ZAPOMNIAŁ, że $y : Trans(know^1(x, y), \neg B(x, y))$.

[x FORGOT that $y : Trans(know^1(x, y), \neg B(x, y))$].

(197) x ZAPOMNIAŁ, że $y : Exp(x, \bigvee_z Trans(know^1(x, y), \neg B(x, y))) \wedge (z = y)$.

[x FORGOT that $y : Exp(x, \bigvee_z Trans(know^1(x, y), \neg B(x, y))) \wedge (z = y)$].

The above interpretations take into account that the processes of remembering or forgetting may be conscious or subconscious. In all four cases y is regarded as a sentence. If y is a name, the verb may be interpreted as follows:

(188) x PAMIĘTA O $y : Exp(x, Trans(R^1_3\ (x, y), R^1_3(x, y)))$.

This signifies that x is aware of the lasting mental contact with y (in this case a reference to the functor *Exp* seems mandatory).

As regards x *zapomniał* y (x forgot y; if y is a proper name), the expression may be regarded as an abbreviated form of 'x forgot to take y', which, in turn, signifies: 'x should have taken y, but did not, without the

intention of not taking *y*'. The case is rather complicated and shall not be analysed in the present study.

(189) x WOLI, żeby y niż żeby z: $\bigvee_{u,w} \bigvee_{t,t'} V_t(x, y_{t'}, u) \wedge V_t(x, z_{t'}, u) \wedge (u > w) \wedge (t < t')$.

[x PREFERS that y than that z: $\bigvee_{t,t'} V_t(x, y_{t'}, u) \wedge V_t(x, z_{t'}, u) \wedge (u > w) \wedge (t < t')$].

In the case of the abbreviated form *x woli y niż z* (x prefers y to z), where both x and z are names, the formula has to be adjusted in the following fashion: y and z (respectively) need to be substituted with $R^1_2(x, y)$ and $R^1_2(x, z)$, or $R^1_3(x, y)$ and $R^1_3(x, z)$, or $R^1_4(x, y)$ and $R^1_4(x, z)$. The choice of the formula is dependent on the context, i.e. on the type of contact between x and y and z, which, in turn, depends on the types of names represented by y and z.

(190) x CHCE (żeby) y: $\bigvee_{t,t'} \bigvee_{i,j} \bigvee_{w,z} B_t(x, Prob(y_{t'}[i, j]) \wedge (j > 0) \wedge V_t(x, y_{t'}, w) \wedge V_t(x, \neg\, y_{t'}, z) \wedge (w > 0) \wedge (z < 0) \wedge (t < t')$.

[x WANTS (that) y: $\bigvee_{t,t'} \bigvee_{i,j} \bigvee_{w,z} B_t(x, Prob(y_{t'}[i, j]) \wedge (j > 0) \wedge V_t(x, y_{t'}, w) \wedge V_t(x, \neg\, y_{t'}, z) \wedge (w > 0) \wedge (z < 0) \wedge (t < t')$].

In the case of the abbreviated form *x chce y* (x wants y), where y is a name, y needs to be substituted with $R^1_{2,t'}(x, y)$ or $R^1_{4,t'}(x, y)$, depending on the type of contact between x and y. This, in turn, is to some extent dependent on the names represented by x and y.

(191) x CHCIAŁBY (żeby) y : $\bigvee_{t,t'} \bigvee_{w,z} V_t(x, y_{t'}, w) \wedge V_t(x, \neg\, y_{t'}, z) \wedge (w > 0) \wedge (z < 0) \wedge (t < t')$.

[x WOULD WANT (that) y : $\bigvee_{t,t'} \bigvee_{w,z} V_t(x, y_{t'}, w) \wedge V_t(x, \neg\, y_{t'}, z) \wedge (w > 0) \wedge (z < 0) \wedge (t < t')$].

(192) x CHCIAŁBY (żeby) y : $\bigvee_{t,t'} \bigvee_{w,z} know^1{}_t\ (x, \neg\, y_{t'}) \wedge V_t(x, y_{t'}, w) \wedge V_t(x, \neg\, y_{t'}, z) \wedge (w > 0) \wedge (z < 0)$.

[x WOULD WANT (that) y : $\bigvee_{t,t'} \bigvee_{w,z} know^1{}_t\ (x, \neg\, y_{t'}) \wedge V_t(x, y_{t'}, w) \wedge V_t(x, \neg\, y_{t'}, z) \wedge (w > 0) \wedge (z < 0)$].

The differences between the formulas (190), (191) and (192) stem from the following: (190) pertains to wanting something that x considers possible (whether this belief is justified or not relevant), while (191) describes a wish which x considers impossible to come true and referring to the future. Lastly, (192) refers to a situation in which x wishes for something impossible to happen in the present or to have happened in the past. The wishes expressed

in (191) and (192) are nothing more but dreams.

(193) x DĄŻY (do tego żeby) y: $\bigvee\limits_{t,t',t''}\ \bigvee\limits_{i,j,m,n}\ \bigvee\limits_{u,w}\ \bigvee\limits_{z} B_t(x, Prob(y_{t'}[i, j]) \wedge (j > 0)) \wedge V_t(x, y_{t'}, u) \wedge V_t(x, \neg\ y_{t'}, w) \wedge (u > w) \wedge B_t(x, Ag_t(x, z_{t''}) \rightarrow (Prob(y_{t'}, [m, n] \wedge (m \geqslant i) \wedge (n > j) \wedge Ag_t(x, z_{t''}) \wedge (t'' \leqslant t') \wedge (t < t'))$.

[x STRIVES for y: $\bigvee\limits_{t,t',t''}\ \bigvee\limits_{i,j,m,n}\ \bigvee\limits_{u,w}\ \bigvee\limits_{z} B_t(x, Prob(y_{t'}[i, j]) \wedge (j > 0)) \wedge V_t(x, y_{t'}, u) \wedge V_t(x, \neg\ y_{t'}, w) \wedge (u > w) \wedge B_t(x, Ag_t(x, z_{t''}) \rightarrow (Prob(y_{t'}, [m, n] \wedge (m \geqslant i) \wedge (n > j) \wedge Ag_t(x, z_{t''}) \wedge (t'' \leqslant t') \wedge (t < t'))]$.

Interpretation: x considers a certain future occurrence y to be probable and prefers it to $\neg\ y$; and x thinks that if x acts so that z, then y will be more probable; therefore x acts so that z; z is not subsequent to y.

In the case of the verb *mieć nadzieję* it will be more convenient to use the English equivalent 'to hope that':

(194) x HOPES (that) $y : \bigvee\limits_{i,j}\bigvee\limits_{z} B(x, Prob(y,[i, j]) \wedge (j > 0) \wedge V(x, y, z) \wedge (z > 0)$.

It is equally convenient to refer to the English equivalent in the case of the verb *zdawać sobie sprawę* (*z tego*), *że* — 'to realise that':

(195) x REALISES that $y : Exp(x, Trans(\neg\ B(x, y), know^1(x, y))$.

(196) x DOWODZI, że $y : \bigvee\limits_{z} S(x, y) \wedge Ag(x, Trans(\neg\ B(z, y), know^1(x, y)))$.

[x PROVES that $y : \bigvee\limits_{z} S(x, y) \wedge Ag(x, Trans(\neg\ B(z, y), know^1(x, y)))$],

(197) x PRZEKONUJE y, że $z : S(x, z) \wedge Ag(x, Trans(\neg\ B(y, z), B(y, z)))$.

[x convinces y that $z : S(x, z) \wedge Ag(x, Trans(\neg\ B(y, z), B(y, z)))$].

The difference between (196) and (197) is based on the fact that in the case of (196) the message conveyed needs to be true, whereas in (197) it is not a necessary condition.

(198) x WYJAŚNIA *y-owi* (że) $z : Ag(x, Trans(\neg\ understand^i(y, z), understand^i(y, z))) \wedge (i = 1, 3, 4)$.

[x EXPLAINS to y (that) $z : Ag(x, Trans(\neg\ understand^i(y, z), understand^i(y, z))) \wedge (i = 1, 3, 4)$].

Interpretation: x acts so that y understands that z. The verb 'understand' is used in the meaning labelled as *rozumieć*^{1}(*understand*^{1}), *rozumieć*^{3}(*understand*^{3}) or *rozumieć*^{4}(*understand*^{4}; cf. (159) — (162)). In the case of *rozumieć*^{4}the veracity of the z being explained is a necessary condition, which constitutes one of the differences between the verbs *wyjaśniać* and *dowodzić* (to prove).

(199) x DEFINIUJE $y : \bigvee_{w} \bigvee_{z} know^1(x, R_1^3(z, w)) \wedge S(x, R_1^3(z, w) \wedge R_1^3(y, w))$.

[x DEFINES $y : \bigvee_{w} \bigvee_{z} know^1(x, R_1^3(z, w)) \wedge S(x, R_1^3(z, w) \wedge R_1^3(y, w))$].

(200) x SUGERUJE, że $y : \bigvee_{z} strive(x, B(z, y))$.

[x SUGGESTS that $y : \bigvee_{z} strive(x, B(z, y))$].

(201) x SUGERUJE, że $y : \bigvee_{z} \bigvee_{i,j}, j\ (know^1(z, x) \rightarrow Prob(B(z, y), [i, j])) \wedge significant(i, j)$.

[x SUGGESTS that $y : \bigvee_{z} \bigvee_{i,j}, j\ (know^1(z, x) \rightarrow Prob(B(z, y), [i, j])) \wedge significant(i, j)$].

Formulas (200) and (201) represent two different meanings of the verb *sugerować* (to suggest). In the former, x is a person, whereas in the latter case x is a certain fact facilitating the formation of a given opinion (in the person noticing that fact).

The verb *grać* (to impersonate, to imitate; as in a theatrical performance) may be represented as:

(202) x GRA $y : \bigvee_{z} S(x, x = y) \wedge know^1(x, \neg (x = y)) \wedge \neg strive(x, B(z, x = y)) \wedge strive(x, R_1^3(z, y))$.

[x IMITATES $y : \bigvee_{z} S(x, x = y) \wedge know^1(x, \neg (x = y)) \wedge \neg strive(x, B(z, x = y)) \wedge strive(x, R_1^3(z, y))$].

(203) x PROSI y (żeby) $z : \bigvee_{t,t',t'',t'''} (z = z(y)) \wedge strive_t(x, realise_{t'}\ (y, hope_t(x, Ag_{t''}(y, z_{t'''})))) \wedge (t \leqslant t') \wedge (t' < t'') \wedge (t'' \leqslant t'')$.

[x ASKS y (that) $z : \bigvee_{t,t',t'',t'''} (z = z(y)) \wedge strive_t(x, realise_{t'}\ (y, hope_t(x, Ag_{t''}(y, z_{t'''})))) \wedge (t \leqslant t') \wedge (t' < t'') \wedge (t'' \leqslant t'')$].

(204) x OBIECUJE (że) $y : \bigvee_{z} \bigvee_{t,t',t''} (y = y(x)) \wedge strive_t(x, B_{t'}(z, Ag_{t'}(x, y_{t''}))) \wedge (t \leqslant t') \wedge (t' \leqslant t'') \wedge (t < t'')$.

[x PROMISES (that) $y : \bigvee_{z} \bigvee_{t,t',t''} (y = y(x)) \wedge strive_t(x, B_{t'}(z, Ag_{t'}(x, y_{t''}))) \wedge (t \leqslant t') \wedge (t' \leqslant t'') \wedge (t < t'')$].

(205) x ZNAJDUJE^1 y: $\bigvee_{t,t'i,j} (t' < t) \wedge Exp_i(Trans_t(\neg R_2^1(x, y), R_2^1(x, y))) \wedge \neg B_{t'}(x, Prob(R_2^1(x, y), [i, j]) \wedge significant(i, j))$.

[x FINDS^1 y: $\bigvee_{t,t'i,j} (t' < t) \wedge Exp_i(Trans_t(\neg R_2^1(x, y), R_2^1(x, y))) \wedge \neg B_{t'}(x, Prob(R_2^1(x, y), [i, j]) \wedge significant(i, j))$].

(206) x SZUKA $y : know^1(x, \neg R_2^1(x, y)) \wedge strive(x, R_2^1(x, y))$.

[x SEEKS $y : know^1(x, \neg R_2^1(x, y)) \wedge strive(x, R_2^1(x, y))$].

(207) x ZNAJDUJE^2 y: $\bigvee_{t,t'}$ $seek_t(x, y) \wedge Ag_{t'}(x, Trans(\neg R_2^1(x, y), R_2^1(x, y))) \wedge (t \leqslant t')$.

[x FINDS^2 y: $\bigvee_{t,t'}$ $seek_t(x, y) \wedge Ag_{t'}(x, Trans(\neg R_2^1 (x, y), R_2^1(x, y))) \wedge (t \leqslant t')$].

The meaning of the verb *osiągnąć* equivalent to the English 'to succeed in doing something' may be represented as:

(208) x SUCCEEDS (in) y : $strive(x, y) \wedge Ag(x, y)$.

(209) x ZDĄŻYŁ y : $\bigvee_{t,t'i,j}\bigvee Ag_t(x, y) \wedge (t \leqslant t') \wedge \bigvee_{t''>t'}$ $Prob(Ag_{t''}(x, y), [i, j] \wedge (j = 0)$.

[x MADE IT IN TIME to y : $\bigvee_{t,t'i,j}\bigvee Ag_t(x, y) \wedge (t \leqslant t') \wedge \bigvee_{t''>t'}$ $Prob(Ag_{t''}(x, y), [i, j] \wedge (j = 0)$.]

The meaning of the verb *zdążyć* requires us to abandon the rule of presenting example phrases in the present tense.

Many of the formulas presented above do not encompass the full scope of the meaning of the verb they pertain to. Several interpretations require additional clarification (e.g. the formula for *definiować*). Moreover, the analysis of the verb *grać* (to act; to imitate; used in the theatrical sense) necessitates significant modifications in the formal description of the verb *kłamać* (to lie). It is not sufficient to interpret *kłamać* as: to inform that p while being convinced that not-p, since in this case an actor playing their role would have to be accused of lying. Thus, the formula for the verb *kłamać* should be amended to:

(210) x KŁAMIE (że) y : $\bigvee_{z}$ $S(x, y) \wedge B(x, \neg y) \wedge strive(x, B(z, y))$.

[x LIES (that) y : $\bigvee_{z}$ $S(x, y) \wedge B(x, \neg y) \wedge strive(x, B(z, y))$].

Interpretation: x informs that y while being convinced that not-y and x strives for other people to be convinced that y. This last part of the formula differs from the interpretation of the verb *grać*(to imitate, to act). (This is analogous to *udawać* — 'to pretent' — but in the case of the latter verb $y = y\ (x)$.)

To interpret the polysemantic verb *móc* we shall utilise its English equivalents 'can' and 'may'. The meaning of 'can' encompasses one of the meanings of *móc* (equivalent to that of *potrafić*). 'May' will be divided into two sub-categories, may^1 and may^2 — the former meaning deals with probability, the latter is deontic.

(211) x CAN y : $\bigvee_{i,jt,t'}\bigvee strive_t(x, y) \rightarrow\ (Prob(Ag_{t'}(x, y), [i, j]) \wedge (j > 0) \wedge (t \leqslant t')$.

Perhaps the interpretation should be slightly more complex — it may be argued that the *definiens* ought to refer to a belief held by the speaker. In this case the formula would take the following form (the elements of the formula were rearranged for purely technical reasons):

(212) x CAN $y : \bigvee_{i,jt,t',t''} (t \leqslant t') \wedge (t'' < t) \wedge B_{t''}(s, strive_t(x, y) \rightarrow (Prob(Ag_{t'}(x, y), [i, j]) \wedge (j > 0)))$.

(213) x MAY^1 $y : \bigvee_{i,j} (y = y\ (x) \wedge B(s, Prob(y), [i, j]) \wedge (j > 0)$.

The temporal relation between the moment of s having a given belief and the moment of y occurring is not specified, since the verb may pertain to past events regarded by the speaker as possible (if the speaker has not been informed whether the occurrence had taken place or not).

(214) x MAY$^2 y : \bigvee_{i} \bigvee_{z} \bigvee_{t,t'} (Ag_t(x, y) \rightarrow P_{i,t'}(x)) \wedge (V(x, P_i(x), z) \vee V(s, P_i(x), z) \wedge \neg (z < 0) \wedge (t \leqslant t')$.

Interpretation: if x acts so that y then x will enter a certain state which is not valued negatively by x or the speaker (or both).

A very similar differentiation may be observed in the case of the meaning of *powinien*^{1} ('should'; dealing with probability) and *powinien*^{2} ('should'; deontic).

(215) x POWINIEN^1 $y : \bigvee_{k}\bigvee_{i,j} (y = P_k(x)) \wedge B(s, Prob(y, [i, j]) \wedge large(i, j))$.

$[x$ SHOULD^1 $y : \bigvee_{k}\bigvee_{i,j} (y = P_k(x)) \wedge B(s, Prob(y, [i, j]) \wedge large(i, j))]$.

The use of the verb *musieć* (must) when referring to probability constitutes a special case:

(216) x MUSI^1 $y : \bigvee_{k}\bigvee_{i,j} (y = P_k(x)) \wedge B(s, Prob(y, [i, j]) \wedge (i = 1))$.

Formulas (213), (215) and (216) do not specify the temporal relation between the moment in which the speaker asserts their belief and the moment of y occurring. The only difference between the three formulas consists in the perceived level of y's probability. The fact whether y is categorised as $y(x)$ or $P_k(x)$ is of secondary concern; a mere matter of notation: it may be assumed that $P_k(x)$ is a special case of $y(x)$.

(217) x POWINIEN^2 $y : \bigvee_{i} \bigvee_{z} \bigvee_{t,t'} (t \leqslant t') \wedge (\neg\ Ag_t(x, y) \rightarrow P_{i,t'}(x)) \wedge (V(x, P_i(x), z) \vee V(s, P_i(x), z) \wedge (z < 0)$.

$[x$ SHOULD^2 $y : \bigvee_{i} \bigvee_{z} \bigvee_{t,t'} (t \leqslant t') \wedge (\neg\ Ag_t(x, y) \rightarrow P_{i,t'}(x)) \wedge (V(x, P_i(x), z) \vee V(s, P_i(x), z) \wedge (z < 0)]$.

Interpretation: if x does not act so that y, then x will enter a certain

state which is valued negatively by x or the speaker (or both). The state may be interpreted as a type of a sanction (ethical, legal social, etc.). Moreover, the disjunction appearing in the *definiens* of formula (217) should perhaps be extended to: $(B(s,\ V(x,\ P_i(x),\ z)))$. This would indicate that the speaker is convinced that x ascribes a negative value to the state, or that it is the speaker that ascribes that value, or that both these statements are true. In this case (217) would contain no direct indication regarding x's own evaluation of the state in question. The decision which form of (217) to accept (i.e. the original notation or the extended one) should depend on the interpretation of the expression presented in the *definiendum*. There seems to be no easy answer to this question, as expressions such as the one appearing in the *definiendum* of (217) are used in a rather intuitive fashion. The more elaborate formula seems a safer option, and the method of notation adapted in the present analysis allows for its extension to be introduced easily.

The verb *powinien* may be used in yet another sense, which is also deontic, but more complex than the one already discussed. The meaning shall be represented as *powinien*$^{2'}$ and appears in phrases such as *numer rejestracyjny pojazdu powinien być widoczny* (the vehicle registration plate should be visible). In formula (215) the categorisation of x is not specified: it can be a human being, a social group, a living organism, a meteorological phenomenon, etc. In (217), however, x is a human being or a group — this is due to the fact that x appears as the first element in the relation V, i.e. the entity that ascribes a given value to a given experience. Even if we choose the extended version of the formula, we need to assume that the speaker is granting x the status of an evaluating entity. The sentence about the registration plate represents a different set of circumstances; consequently, the verb requires a different interpretation:

(218) x POWINIEN$^{2'}$ $y : \bigvee\limits_{i,j}\bigvee\limits_{w}\bigvee\limits_{z}\bigvee\limits_{t,t'} (y = P_i(x)) \wedge (\neg\ Ag_t(w,\ P_i(x)) \rightarrow P_{j,,t'}(w)) \wedge (V(x,\ P_j(w),\ z) \vee\ V(s,\ P_j(w),\ z) \wedge (z < 0) \wedge (t \leqslant\ t'))$.

$[x$ SHOULD$^{2'}$ $y : \bigvee\limits_{i,j}\bigvee\limits_{w}\bigvee\limits_{z}\bigvee\limits_{t,t'} (y = P_i(x)) \wedge (\neg\ Ag_t(w,\ P_i(x)) \rightarrow\ P_{j,,t'}(w)) \wedge (V(x,\ P_j(w),\ z) \vee\ V(s,\ P_j(w),\ z) \wedge (z < 0) \wedge (t \leqslant\ t'))]$.

Interpretation: there exists a w, which is a human being or a group and is the subject of a certain sanction if not-y, i.e. if x is not in a certain specified state. In the case of our example sentence, someone will be held accountable for the fact that the registration plate on a specific vehicle is not visible. Naturally, the disjunction in the *definiens* of (218) could be extended similarly to that of (217).

(219) x POSTANAWIA (że) $y : \bigvee_{t,t'} (y = y\ (x)) \wedge (t < t') \wedge Exp_t(x, Trans_t(\neg\ want(x,\ y),\ want(x,\ y))) \wedge B_t(x,\ strive_{t'}(x,\ y))$.

$[x$ DECIDES (that) $y : \bigvee_{t,t'} (y = y\ (x)) \wedge (t < t') \wedge Exp_t(x,\ Trans_t(\neg\ want(x,\ y),\ want(x,\ y))) \wedge B_t(x,\ strive_{t'}(x,\ y))]$.

It must be remembered that $\neg\ want$ is to be interpreted as 'it is not so that n wants' rather than as 'n does not want' (which could be represented as *not-want*). In the case of 'n does not want' the negation is much stronger than a simple negation; the phrase 'n does not want that m' is equivalent to 'n wants that not-m'. The statement communicated in formula (219) is not as strong.

Descriptions of verbs pertaining to intellectual processes are relatively complicated and may raise questions. The amount of controversy will depend largely on the interpretation of the said mental processes e.g. within the methodology of science. Such discrepancies may affect the description of the meaning of a given verb, yet belong to the realm of the extra-linguistic. Interpreted as they are in methodology, verbs referring to intellectual processes do not seem to be a part of natural languages *sensu stricto*, because in natural languages they are used in a rather intuitive and even naive fashion. The two examples presented below are included for reference only and serve to demonstrate the method of describing such verbs in accordance with the general assumptions of the present analysis. It seems that the possible differences in interpretation resulting from differing methodological approaches to the verbs may be reflected in the corresponding formulas. Therefore, at least in certain cases one may assume that specific elements of the formal notation are merely abbreviated references to certain methodological assumptions, which may be very intricate. Such an approach seems justified, especially in the light of the — already mentioned — fact that the nuances of methodological interpretation go beyond the meaning of any given verb, or at least those of its meanings that are closest to the colloquial uses.

(220) x BADA $y : \bigvee_{i,j} \bigvee_{k} \bigvee_{t,t'} (t < t') \wedge B_t(x,\ Prob(P_k(y),\ [i,\ j]) \wedge (j > 0) \wedge strive_{t'}(x,\ know^2{}_{t'},\ (x,\ P_k(y)))$.

$[x$ ANALYSES $y : \bigvee_{i,j} \bigvee_{k} \bigvee_{t,t'} (t < t') \wedge B_t(x,\ Prob(P_k(y),\ [i,\ j]) \wedge (j > 0) \wedge strive_{t'}(x,\ know^2{}_{t'},\ (x,\ P_k(y)))]$.

Interpretation: x starts with a working hypothesis assuming that y may be in the state of P_k and strives to ascertain whether it is indeed so; $know^2$ represents *wiedzieć, czy...* (to know whether).

(221) x WNIOSKUJE (że) y : $\bigvee_{t,t',t'',t'''} \bigvee_{i,j,m,n,p,q} \bigvee_{z} (t \leqslant t' \leqslant t'') \wedge (t' < t'') \wedge (t''' \leqslant t') \wedge B_t(x, Prob(y, [i, j]) \wedge (j \geqslant 0) \wedge B_{t'}(x, Prob(z_{t'''}, [m, n]) \wedge B_{t''}(x, Prob(z_{t'''}, [m, n]) \rightarrow Prob(y, [p, q])) \wedge (p \geqslant i) \wedge (q > j) \wedge (p \leqslant m) \wedge (q \leqslant n)$.

$[x$ INFERS (that) y : $\bigvee_{t,t',t'',t'''} \bigvee_{i,j,m,n,p,q} \bigvee_{z} (t \leqslant t' \leqslant t'') \wedge (t' < t'') \wedge (t''' \leqslant t') \wedge B_t(x, Prob(y, [i, j]) \wedge (j \geqslant 0) \wedge B_{t'}(x, Prob(z_{t'''}, [m, n]) \wedge B_{t''}(x, Prob(z_{t'''}, [m, n]) \rightarrow Prob(y, [p, q])) \wedge (p \geqslant i) \wedge (q > j) \wedge (p \leqslant m) \wedge (q \leqslant n)]$.

Interpretation: x holds a certain belief regarding the probability of y, and in x's opinion the probability increases due to z but in such a manner that it does not exceed the probability of z as seen by x (where z represents the premises for the inference). This interpretation only refers to the correctness of the inference and does not imply the veracity of z nor, consequently, the veracity of y.

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The interpretations presented in this work should be regarded as preliminary and incomplete. The issue of interpreting verbs is exceedingly problematic, as in many cases verbs are understood in a rather intuitive fashion; the nuances of their meaning are not easy to specify. In other cases colloquial uses differ greatly from the manner in which a given verb is employed in professional or specialised contexts. The categorisation of arguments also requires work. To make matters worse, some verbs only take arguments belonging to a very narrow category. In other cases still, the principle of reistic interpretation adapted in the present study for practical reasons forces us to present a description which differs considerably from habitual uses.

The present study contains the analysis of just a handful of verbs. Many of the disregarded ones would require a very elaborate interpretation, especially in formal notation. E.g. *winić kogoś za coś* (to blame somebody for something) may be interpreted as: to be convinced that someone did not act as they could and should have acted. This raises the question of whether the interpretation of *powinien*^{2} (should^2) ought to include an element implying that someone should do something and that they have a possibility of doing this. This seems to be an accurate interpretation of the verb in question, yet it is not entirely clear if its use (at least in colloquial language) entails such a semantic element. Many more analyses will be needed to extract all such nuances of meaning.

The methods of analysis and formal description of the meanings of

verbs adopted in the present work is by no means regarded as the only possible solution or advertised as the best. Any possible criticism should above all target inconsistencies and/or contradictions that might have found their way into the system, or point to other, simpler or more convenient solutions for the problems delineated in the analysis.

Despite the incompleteness of the interpretations presented in this work and the controversies associated with them, publishing the analysis at its present stage seems justified due to the significance of the issues it tackles and on the grounds that works presenting a large number of verbs are relatively few. The apparatus used does not appear to be overly complex.

The present work makes use of various published and unpublished ideas and concepts proposed by O. A. Wojtasiewicz and B. Bojar and related to the analysis of verbs and syntax conducted in the Chair of Formal Linguistics at the University of Warsaw. A number of ideas were introduced by scholars working at this institution — A. Bogusławski and Z. Saloni. Others were directly or indirectly inspired by various works of Morris, Hintikka, Ajdukiewicz, Lakoff and other scholars, mostly from the United States and the U.S.S.R. Given the sheer amount of relevant literature, in many cases the author of a given concept is difficult or even impossible to identify, since the idea has since been adopted and utilised numerous times. The work shall be continued so that, among other things, its results can be used in developing a semantic code.

Postscriptum. The principles of description presented above are not final and shall presumably undergo many modifications and will certainly be extended, since a great number of verbs have not yet been analysed. Even at this stage, however, some elements may already be amended or at least reassessed. If the relation of $R^1_y(x, z)$ (cf. (37)) is interpreted as 'x is a(n) y of z' or 'x is a(n) y for z' or 'x is in a relation y towards z', then the looser interpretation of 'x and z are in a relation delineated by y' may seem too vague. However, the benefits of adopting the more precise interpretation are considerable. In the case of 'x *wiosłuje*' (x rows; cf. (60)) we arrive at: 'x acts so that an oar is an oar to x', i.e. 'x uses an oar as an oar'. In this case, the verb *matkować* (to mother; cf. (61)) would have to be interpreted as: 'x acts so that x is a mother to y'. The question whether the differences in notation between (37) 'x is a mother to y' and (61) suffice to express the difference between 'being someone's mother' and 'mothering someone' remains open (naturally, to compare the formulas we would have to change the variables in (37) to $R^1_z(x, z)$, yet this is a purely technical matter).

If — perhaps justifiably — the more specified interpretation is

adopted, the notation in (64) requires changes, otherwise we would arrive at 'x is a ford to y'. The new version of the formula would be:

(64a) $R^1_z(x,\, y) \wedge Ag(x,\, R^1_z(z,\, x)) \wedge (y \in \ \mathit{Inland\ Waters})$,

which should be interpreted as: 'a ford is a ford (in relation) to y and x acts so that a ford is a ford to x'.

A different type of emendation may be introduced to (104). A more accurate formula would be:

(104a) $\bigvee\limits_{w,z} R^1_4(x,\, w) \wedge L(w,\, z) \wedge P_y(w) \wedge (x \in \ \mathit{Hum})$,

i.e. x lives in a given flat the state of which is delineated by y.