ℜeALIS2.1: The Implementation of Generalized Intensional Truth Evaluation and Expositive Speech Acts in On-Going Discourse

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***Abstract*—Our software application ℜeALIS2.1 (just like ℜeALIS1.1) is primarily intended to supply linguists with a highly intelligent device to build fragments of languages. On the basis of the fragments, (non-linguist) experts can elaborate a peculiarly "multiplied" database that offers, besides the model of the external world, hundreds of its (appropriately labeled) alternatives. According to the ℜeALIS theoretical framework that we use (ℜeALIS: *Reciprocal and Lifelong Interpretation System*), these alternative models can all be linked to simulated human agents (addressers and addressees of possible discourses), who are represented in the world model as conglomerates of their pieces of knowledge, beliefs, desires, and intentions. Finally, (further) users can select lexical items to build sentences, the truth-conditional interpretation of which the program can calculate on the basis of the actual version of the above-sketched "multiplied world model". It performs this after checking whether the given sentences can serve as felicitous expositive speech acts in realistic on-going discourses. Our software application serves not only the theoretical purpose of testing ℜeALIS as a Discourse-Representation-Theory-based "pragmalinguistics" approach (by implementing it), but it also serves the practical purpose of collecting and systematizing data in the peculiar structure that ℜeALIS offers. It is a crucial feature of ℜeALIS that it is intended to truly capture human intelligence (more precisely, such sapiens-specific components of long-term memory as episodic memory, with its space-time coordinates, and semantic memory, containing context-free knowledge).**

Keywords—dynamic discourse semantics; possible worlds; truth-conditional interpretation; speech acts; presupposition.

I. INTRODUCTION

We are working on the implementation of a pragma-linguistics theory, ℜeALIS, intended to truly capture human intelligence by means of a peculiarly multiplied world model [1] [2] [3]. We consider the implementation of this "intelligent" structure [4] [5] [6] our primary innovation.

The point of departure to our research work is a linguistics theory whose representatives, in the course of describing human language(s) and explaining their structure and functioning, have been led to a conclusion that may seem to be quite strange at first glance: revealing the "internal" secrets of language (including non-pragmatic and non-cognitive phenomena as well) depends on the substantial capturing of an external factor. This factor is information states of human minds in communication, changing from second to second [7] [8]. It is this factor that must be modeled in a way that we can account for the facts that we are interlocutors reciprocally "reflecting" each other's minds [9] [10] [11] and that our momentary information states contain even pieces of information obtained decades earlier. In essence, it is the human mind itself that is to be modeled according to special aspects and requirements [12] [13].

Is this a huge cost for the treatment of internal questions of language?

Our answer is 'no' to this question, because it is possible to elaborate a sufficiently simple plausible mathematical model [3] (see Section III). The promising benefit, however, opens up new prospects in two fields, in which we intend to continue to conduct research, besides linguistic phenomena in a narrow sense of the term. One field is basing the innumerable kinds of computational processing of human language upon data arranged according to human intelligence or the "model of minds in communication" [11] [14] [15]. The other field has to do with the scientific description of mental disorders: it is via inspecting the impaired mind, on the one hand, that we can approach to understanding the driving forces for language, and, on the other hand, it is via studying language that the decisive features of autism or schizophrenia, for instance, can be captured [16]. In the neuropsychiatric field of our research, we explain what causes information loss and deficiency in these conditions [17].

After sketching this broad picture, we restrict ourselves, in what follows, to dealing with the pragmalinguistics [5], mathematical [3] and "technical" [18] [19] [20] apparatus of ℜeALIS, which makes its implementation immediately possible.

Let us now overview the structure of the paper. Section II sketches the current version of ℜeALIS, primarily its radical ontological innovation relative to Discourse Representation Theory (DRT [21] [22]), which underlies it. Then the decisive elements of the mathematical definition of ℜeALIS are presented, in Section III. Section IV is devoted to the demonstration of the new results in pragmatics in the ℜeALIS framework, which have strengthened our earlier guideline. The point is that in the case of an utterance, it is to be checked whether the speaker, the hearer and the given situation are suitable for serving as the addresser, the addressee and the context of the linguistically defined speech act [23] [24], which simply requires a truth-conditional investigation [25] primarily into the addresser's mind's certain "worldlets". The task boils down to get to the worldlets in which certain polarity values must then be checked. Then our software application ℜeALIS1.1 is

demonstrated in Section V through discussing its different kinds of potential users and its main use cases for the users we call internal users and for those we call external users. Section VI demonstrates the analysis of some linguistic examples with the purpose of elucidating our ambition to capture the highest possible level of human intelligence coded in language. It is presented how our generalized truth evaluation can be applied to such complicated linguistic phenomena as tense, aspect, subjectivity, deixis, among others. Finally, Section VII presents the additional services of ℜeALIS2.1 as compared to ℜeALIS1.1 and an SDRT-based (Segmented DRT [22])) experimental software application called RUDI [26]. We point out that ℜeALIS2.1 can be regarded as a model of the two parts of long-term memory—episodic and semantic memory—and this enables us to derive a potentially infinite number of senses for words from finite lexical resources.

II. THE CURRENT VERSION OF ℜEALIS AND THE "STATE OF THE ART"

ℜeALIS is based on Discourse Representation Theory, often referred to as DRT [27] [28]; it can thus be introduced as belonging to the family of representational dynamic discourse semantics. Its complete (forty-page-long mathematical) definition is available at [2]; the relevant details will be given in Section III. It is intended in ℜeALIS to reconcile the formal exactness of generative syntaxes [29] [30] [31] (and their adaptations to Hungarian [32] [33] [34]) and the dynamic approach of optimality theories [35] and the aforementioned (S)DRT with basically Austinian [36] speech-act theories [37] [38], bearing in mind the holistic stance of cognitive linguists [39] [40].

In the post-Montagovian world [25] of formal semantics, DRT—which has offered a revolutionary logics-based solution to the resolution problem of ("donkey") anaphora and attractive visual representations for discourse meaning—is often criticized from "inside" as well as from "outside", considerably weakening its legitimacy. The internal criticism comes from the world of the dynamic model-theoretic semantics, from the Amsterdam School [41], and pertains to the (mathematically unquestionable) eliminability of exactly this attractive visual representation, insisting on "Montague's heritage" [25]. The external criticism comes from experts of philosophy /pragmatics [42] and representatives of the Proof-Theoretic School [43], among others [44]; they all point at the dubious status and construction of *possible worlds* (among others).

Pollard [44], for instance, is led to the following conclusion pertaining to the mainstream Kripke/Montague-inspired possible-worlds semantics: "the idea of taking worlds as a primitive of semantic theory is a serious misstep." He calls it [44] "a framework known to have dubious foundations."

Even the seminal book of teaching Montague Grammar [25] admits these "dubious foundations" in the course of discussing the problem of necessity and possibility: "Would this be an enlightening way of analyzing the semantics of necessity [e.g., *Alfred must be a bachelor*] and possibility [e.g., *Alfred may be a bachelor*]? Many philosophers of language have unequivocally answered "no" to this question; they have contended that since "possible worlds" are surely vague and ill-understood entities..., it cannot help to explain one mysterious semantic concept (necessity) in terms of an even more mysterious one (possible worlds)."

The same is still "reported" in 2014.

Judge [45], for instance, who works in the standard, Kratzerian [46] [47] framework of modality (based on the Kripke/Montague-inspired possible-worlds semantics), "admits" that "describing the semantics of uncertainty is problematic – particularly for semantic theories that are reliant on truth-conditional definitions of meaning;" and she designates the pertinent relationship between formal semantics and pragmatics as follows: "...ideally a linguistic theory will account for how natural language works in real conversational contexts, and not be restricted to only accounting for logical output, (not least because extricating the core/logical meaning of a linguistic expression from the contributions of context is highly problematic). Indeed, modality is an area of semantics where understanding the systematic interactions of context and underlying form is particularly pertinent." Note that Judge's evaluation even on her own solution proposed in [45] is definitely low-key: "The proposal of the certainty set is intended as an experiment, rather than a full-blown, conclusive solution to the puzzles of modal expressions. By refashioning the knowledge set as a certainty set some interesting patterns and solutions are suggested. However, problems remain particularly with characterising degrees of modality, the epistemic modality/ evidential" distinction, [among others]..."

Marsali [42], whose approach is philosophical /pragmatic, "...refuses to adopt the semantic account of EMM [epistemic modality markers, such as *maybe*, *probably*, *certainly*, *definitely*] on the ground of ... [the reason that] it is not clear how EMM should be interpreted, and countless incompatible semantic accounts of EMM have been presented in the philosophical literature ... But it is implausible to contend that EMM fix the truth conditions of [say, a] statement like *Certainly it is raining in England*, if there is no agreement on what are the truth conditions of [a statement like this]."

It is also worth mentioning on the basis of [7] that "221 *may* be a good choice" is as reasonable a reaction to the proposal "We need a prime number greater than 200" as the reaction "211 *may* be a good choice," in contrast to the unreasonable reaction "300 *may* be a good choice." The problem (for possible-worlds semantics) is that 211 is a prime number, indeed, while $221=13\cdot17$. There is no possible world, thus, in which 221 is a prime number (or, in an absurd system of possible worlds, even 300 can qualify as a prime number).

We claim that ℜeALIS—while considerably relying on the representationalism of DRT in the course of solving a wide range of linguistic problems in order to maximally exploit and develop the excellent facilities provided by this representationalism—offers exactly the radical ontological innovation that has to do with the elimination of the above-

mentioned two dubious levels of representation, discourse representations and possible worlds, referred to as I and III in Fig. 1.

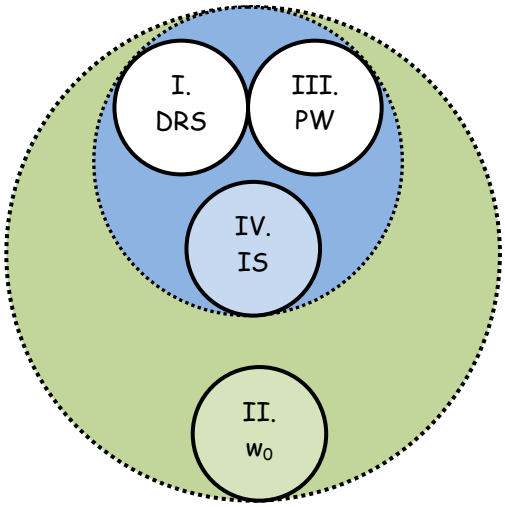


Figure 1. Components / levels of representation in DRT: I-IV; and their re-arranged ontology in ℜeALIS:
I. DRS: the semantic representation of sentences constituting coherent texts
II. Model of the external world (for extensional interpretation)
III. Possible worlds (for intensional interpretation)
IV. Interlocutors' information states

ℜeALIS embeds representational levels I and III—more exactly, their relevant content—in the representation of information states (IV), relying on the approach that, as interlocutors obtain information through discourses, their information states are worth regarding as gigantic, lifelong, DRSs. An information state has a double nature: it functions as a "representation" in the above regard while it is used as "what is to be represented" in the interpretation of, say, the intensional sentence types shown in (2b-d): it also depends on different persons' information states whether these sentences are true, in contrast to sentence (2a), the truth value of which only depends on facts of the external world. Note in passing about the aforementioned "double nature of information states" that modern set theory exactly rests upon a similar idea: Sets and their elements must not be mixed up; this does not mean, however, that a set could not serve as an element of another set.

a. "Ben is a linguist."
b. "Sue knows that/if [Ben is a linguist]"
c. "Joe guesses that Sue definitely wants to convince him to take it for granted that [Ben is a linguist]."

Figure 2. Sentences to be interpreted in different world(let)s.

We are now going to illustrate the descriptive and explanatory power of ℜeALIS by sketching the interpretation of sentence (3a), featuring *realize*, which is a factive verb (NB: similar analyses of ours are available in [8] and [7]). Hence, it is a precondition of interpreting the sentence as true (or rather, as "well-formed") that the Evening Star must coincide with the Morning Star in (the model of) the external world. This means that the entity referred to as the Evening Star by the given astronomer must be the same entity he refers to as the Morning Star. In the approach of ℜeALIS, this relation is captured formally as demonstrated in (3b): the internal entity $r_{EveningStar}$ must be anchored to the same external entity as the internal entity $r_{MorningStar}$.

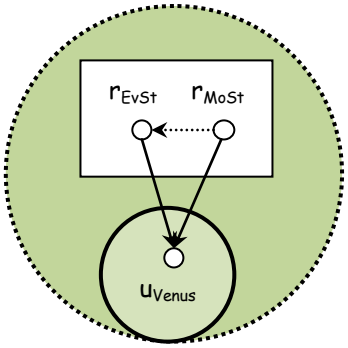


Figure 3. The interpretation of *realize* and the *Venus*-problem
a. "An ancient astronomer realized that the Evening Star is the same as the Morning Star."
b. $\alpha(r_{EvSt})$ is-the-same-as $\alpha(r_{MoSt})$ (since u_{Venus} is-the-same-as u_{Venus})
c. It does not hold that $r_{EveningStar}$ is-the-same-as $r_{MorningStar}$ at τ in the astronomer's worldlet of astronomic hypotheses
d. It holds that $r_{EveningStar}$ is-the-same-as $r_{MorningStar}$ at τ', which is a later point of time in the astronomer's worldlet of astronomic hypotheses

The astronomer himself is not (necessarily) aware of the co-anchoring of the two internal entities at his disposal (in his appropriate worldlet); but the fact of co-anchoring is an external requirement due to the factive character of the verb. Two further requirements to be satisfied in order for sentence (3a) to qualify as true concern two information states of the astronomer at different points of time, independently of the external world: what is to be checked is whether there is a "same-as" relation between the internal entity $r_{EveningStar}$ and the internal entity $r_{MorningStar}$ in the one information state (3d) while they do not stand in the "same-as" relation in the other one (3c)

All in all, three competing world(let) models need to be considered simultaneously ("prism effect"), and three entities—an external one and two internal ones—need to be inspected. As the three models are all parts of the one complete model of the history of the external world and all internal reflections associated with it (see Fig. 2), in this matrix model (3b-d) can all be checked.

It must be noted that the analysis relies on the same facilities available in the cognitive linguistics framework; see, for instance, the paper by Pelyvás [39], who follows Langacker's approach to nominal grounding [48]. The most important tenet of this view is that all nominals are grounded in the "reality" of the Idealized Conceptual Model(s) evoked in the discourse, which is relative to speaker and hearer, rather than directly in objective reality. From the point of view of linguistic analysis the reality that

we could call "objective" (i.e., independent of speakers' and hearers' beliefs) is only of marginal importance.

At this point we call the reader's attention to the obvious fact that our treatment of replacing, in the course of truth-conditional interpretation, a set of possible worlds with the finite (and typically very small) "worldlet" containing the information shared by the given possible worlds opens up new prospects in (the practice of) implementation. With gigantic sets of gigantic possible worlds got rid of, there is already no obstacle to capturing the pragmatic complexity that is claimed to be associated with even simple assertions, which "serve the aim of communicating, not merely pieces of information, but also the speaker's attitude of certainty or uncertainty about them," [38] chiefly due to what are called the ATMM-categories: Aspect [49], Tense, Mood, and (different kinds of) Modality [38] (see also [40], Section 4 in [24], and Section IV-D in the present paper).

We conclude this section by telling some words on the "state of the art". At the moment, we only have world models and alternative-worldlet-set models filled up with small sets of data. Our sophisticated Hungarian lexicon also consists of not more than a few hundreds of words [51] [52] [53], and our English lexicon is even smaller; furthermore, the involvement of these lexical items in parsing [54] also requires highly theory-specific morphological [55], syntactic [57] [56] [58], and semantic [1] [58] [60] tools. Thus, we are in an experimental phase with our software applications. The problem is that it would require very much time, effort, and, hence, money, to elaborate realistic and useful world(let) models. We are also in need of native speakers of English who are willing to help elaborating such sophisticated linguistic descriptions as the Hungarian ones presented in Section IV-D, for instance.

It would be worth elaborating all these costly components if, and only if, such customers appeared in the market who are willing to make our team register the data they work with and the environment they work in according to the peculiar system that ℜeALIS offers. We mean data that someone *actually* works with. The primary aim with this paper is to find such customers. Not only for obtaining financial support for our team of theoretical and computational linguists, most importantly for obtaining realistic conglomerates of data worth working up in the ways demonstrated in this paper.

We intend to convince the reader (and our potential customers) that not only professional spies, intrigants and mind readers are in need of maniulating data registered in multiplied wordlet structures but also detectives, lawyers and judges are, as well as managers and secretaries, psychiatrists and politicians, and practically everyone. It is no coincidence that every human language is well equipped with such communication tools and techniques as those presented in Section IV.D and in certain subsections of Section VI. It may turn out to be important to anyone to be aware of such complex epistemic patterns (concerning human agents A_1, A_2, A_3,... and potential facts ψ_1, ψ_2, ψ_3,...) as the situations sketched in the following paragraphs.

A_1 and A_2 both know ψ with(out) knowing this about each other.

A_1, who knows ψ, wants A_2 to think that he does not know ψ or that he thinks so that ψ is probably false.

A_1 wants to get known from A_2 whether ψ is true or false, but he does not want her to notice this intention.

A_1, who is telling A_2 that ψ is true, is almost sure that A_2 is convinced that he does know whether ψ is true or false.

A_1 knows that A_2 is aware of the fact that ψ is true but he pretends as if he did not know that.

A_1 did not know whether ψ_1 or ψ_2 is true out of two incompatible statements but he had to make a decision. He knew that ψ_1 is true according to A_1, A_2, and A_3, while ψ_2 is true according to A'_1, A'_2, and A'_3. Now he thinks so that ψ_1 is probably true while ψ_2 is probably false. He has made this decision on the basis of the following facts and assumptions: A_1, A_2, and A_3 have proved reliable people in similar cases in which decisions had to be made, in contrast to A'_1, A'_2, and A'_3. Moreover, A_1 suspects that A'_1, A'_2, and A'_3, who have close contact with each other, are interested in his believing in ψ_2, whereas A_1, A_2, and A_3 are likely to have never met each other.

III. The Decisive Elements of the Definition of ℜeALIS

The relevant parts of the mathematical definition of ℜeALIS (whose 40 page long complete version is available in [2]) are summarized here. As interpreters' mind representation is part of the world model, the definition of this model $\mathfrak{R} = \langle U, \mathbf{W_0}, W\rangle$ is a complex structure where

- U is a countably infinite set: the universe;
- $W_0 = \langle U_0, \mathbf{T}, \mathbf{S}, \mathbf{I}, \mathbf{D}, \Omega, \mathbf{A}\rangle$: the external world;
- W is a partial function from I×T where W[i,t] is a quintuple $\langle U[i], \sigma[i,t]^{\Pi}, \alpha[i,t]^{\Psi}, \lambda[i,t]^{\Lambda}, \kappa[i,t]^{K}\rangle$: the internal-world function.

The external world consists of the following components:

- U_0 is the external universe ($U_0 \subset U$), whose elements are called entities;
- $\mathbf{T} = \langle T, \Theta\rangle$ is a structured set of temporal intervals;
- $\mathbf{S} = \langle S, \Xi\rangle$ is a structured set of spatial entities;
- $\mathbf{I} = \langle I, Y\rangle$ is a structured set of interpreters;
- $\mathbf{D} = \langle D, \Delta\rangle$ is a structured set of linguistic signs (practically morph-like entities and bigger chunks of discourses performed),
- where $T \subset U_0$, $S \subset U_0$, $I \subset U_0$, $D \subset U_0$,
- $\Omega \subset T \times U_0^*$ is the set of core relations (with time intervals as the first argument of all core relations),
- **A** is the information structure of the external world (which is nothing else but relation structure Ω reformulated as a *standard simple information structure*, as is defined in [61]; its basic elements are called the *infons* of the external world.

The above mentioned *internal-world function* W is defined as follows:

- The relation structure W[i,t] is called the internal world (or information state) of interpreter i at moment t;

- $U[i] \subset U$ is an infinite set: interpreter i's internal universe (or the set of i's referents, or internal entities); U[i'] and U[i"] are disjoint sets if i' and i" are two different interpreters;
- what changes during an interpreter i's lifespan is not her referent set U[i] but only the four relations among the (peg-like [62] [8]) referents, given below, which are called i's internal functions:
- $\sigma[i,t]^{\Pi} : \Pi \times U[i] \rightarrow U[i]$ is a partial function: the eventuality function (where Π is a complex label characterizing argument types of predicates),
- $\alpha[i,t]^{\Psi} : \Psi \times U[i] \rightarrow U[i] \cup U_0$ is another partial function: the anchoring function (α practically *identifies* referents, and Ψ contains complex labels referring to the legitimizing grammatical factors);
- $\lambda[i,t]^{\Lambda} : \Lambda \times U[i] \rightarrow U[i]$ is a third partial function: the level function (where elements of Λ are called level labels); the level function is intended to capture the "box hierarchy" among referents in complex Kampian DRS boxes [21] enriched with some rhetorical hierarchy in the style of SDRT [22],
- $\kappa[i,t]^{K} : K \rightarrow U[i]$ is also a partial function: the cursor, which points to certain temporary reference points prominently relevant to the interpreter such as "Now", "Here", "Ego", "Then", "There", "You" [38];
- The temporary states of these four internal functions above an interpreter's internal universe serve as her "agent model", or mind representation, in the process of (static and dynamic) interpretation.

Suppose the information structure **A** of the external world (defined above as a part of model $\mathfrak{R} = \langle U, \mathbf{W_0}, W \rangle$) contains the following infon: $\iota = \langle$perceive, t, i, j, d, s$\rangle$, where i and j are interpreters, t is a point of time, s is a spatial entity, d is a discourse (chunk), and 'perceive' is a distinguished core relation (i.e., an element of Ω). The interpretation of this "perceived" discourse d can be defined in our model relative to an external world $\mathbf{W_0}$ and internal world W[i,t].

The dynamic interpretation of discourse d is essentially a mapping from W[i,t], which is a temporary information state of interpreter i, to another (potential) information state of the same interpreter that is an *extension* of W[i,t]; which practically means that the above mentioned four *internal functions* (σ, α, λ, κ) are to be developed monotonically by *simultaneous recursion*, expressing the addition of the information stored by discourse d to that stored in W[i,t].

The new value of eventuality function σ chiefly depends on the *lexical items* retrieved from the interpreter's internal mental lexicon as a result of the perception and recognition of the words / morphemes of the interpreter's mother tongue in discourse d. This process of the identification of lexical items can be regarded as the first phase of the dynamic interpretation of (a sentence of) d. In our ℜeALIS framework, extending function σ corresponds to the process of accumulating DRS condition rows containing referents that are all—still—regarded as different from each other.

It will be the next phase of dynamic interpretation to *anchor* these referents to each other (by function α) on the basis of different grammatical relations that can be established due to the recognized *order* of morphs / words in discourse d and the *case*, *agreement* and other markers it contains. In our approach, two referents will never have been *identified* (or deleted), they will only be anchored to each other; but this anchoring essentially corresponds to the identification of referents in DRSs.

The third phase in this simplified description of the process of dynamic interpretation concerns the third internal function, λ, the level function. This function is responsible for the expression of intra- and inter-sentential scope hierarchy [63] [64] / information structure [32] [33] [34] / rhetorical structure [22], including the embedding of sentences, one after the other, in the currently given information state by means of rhetorical relations essentially in the way suggested in SDRT.

It is to be mentioned that the information-state changing dynamic interpretation and the truth-value calculating *static interpretation* are mutually based upon each other. On the one hand, static interpretation operates on the *representation* of sentences (of discourses) that is nothing else but the output result of dynamic interpretation. On the other hand, however, the above discussed phases of dynamic interpretation (and chiefly the third phase) include subprocesses requiring static interpretation: certain *presuppositions* are to be verified [21] [38].

The interpreter's fourth internal function, cursor κ, plays certain roles during the whole process of dynamic interpretation. *Aspect*, for instance, can be captured in our approach as the resetting or retaining of the *temporal* cursor value as a result of the interpretation of a sentence ($\rightarrow$ non-progressive / progressive aspect, respectively). It can be said in general that the input cursor values have a considerable effect on the embedding of the "new information" carried by a sentence in the interpreter's current information state and then this embedding will affect the output cursor values [65].

Dynamic interpretation in a ℜeALIS model $\mathfrak{R}=\langle U, \mathbf{W_0}, W \rangle$, thus, is a partial function Dyn that maps a (potential) information state W° to a discourse d and an information state W[i,t] (of an interpreter i):

- $\mathrm{Dyn(d)} : \langle \mathfrak{R}, W[i,t] \rangle \mapsto \langle W^{\circ}, \underline{e^{\circ}}, \mathbf{U^{\circ}} \rangle$,
- where $\mathbf{U^{\circ}}$, shown up in the output triple, is the cost of the given dynamic interpretation (coming from presuppositions legitimized by *accommodation* instead of *verification*), and $\underline{e^{\circ}}$ is the eventuality that the output cursor points to (this is the eventuality to be regarded as representing the content of discourse d). Function Dyn(d) is *partial*: where there is no output value, the discourse is claimed to be ill-formed in the given context. Due to the application of cost, ill-formedness is practically a gradual category in ℜeALIS.

The static interpretation of a discourse d is nothing else but the static interpretation of the eventuality referent that represents it. The recursive definition of static interpretation

is finally based upon anchoring internal entities of interpreters to external entities in the external universe, and advances from smaller units of (the sentences of) the discourse towards more complex units.

The "prism effect", mentioned in Section II, is worth to be given a separate definition in the system of ℜeALIS, as follows, because our linguistic illustrations are practically based on this single formula.

A clause performed in a context conveys an infon that belongs to an *intensional profile*, which is an element of the set defined below: the power set of the set of finite sequences of a particularly specialized set of the above-defined level labels. The clause is to be interpreted against the (possible-world-like but finite) components of this intensional profile in order to obtain its truth conditions and other semantic and/or pragmatic well-formedness conditions in the given context.

$$\mathscr{P}((\mathrm{M}\times\mathscr{P}(\mathrm{I})\times\mathrm{P}\times\mathrm{T}\times\mathscr{P}(\{+,-,0\}))^*) = \mathscr{P}(\Lambda^*) \qquad (1)$$

The theoretically highly important mathematical exactness, which this formula is intended to suggest, provides a simple, straightforward, uniform, well motivated, and "user-friendly" approach to reach the ultimate aim of pragmalinguistics [66] [67]: to account for the use of the semantic content of the sentences performed in a certain context (see also [45]).

Let us start the elaboration of the details with set M in formula (1): it is the set of modal labels that say whether an infon serves to someone as some kind of belief (BEL), or desire (DES), or intension (INT), or anything else ([5]; see also [38]). Mann [68] establishes that "[p]erhaps the most important distinction for modeling the intentions that accompany language use is a contrast between intended actions and intended effects. Intended effects typically are states of affairs that the intender desires or prefers, while intended actions typically involve some identifiable process within the capacities of the actor(s)." On the basis of this, 'intended effects' are called desires (DES) in ℜeALIS.

Set I provides degrees for expressing the intensity of the given modality, from "maximum" (MAX or M) through "great" (gr) up to "some" (sm). Associated with the modality BEL, for instance, this scale ranges from sure knowledge to weak conjecture. There must be "uncertain" degrees between "known" and "unknown" [69]. The *muss/soll/will* triplet of German epistemic modal auxiliary verbs can be regarded as evidence for the existence of at least three non-maximal degrees [38]. It requires much future research to decide how many degrees have a linguistic relevance in the certainty-uncertainty continuum [42]. The power set $\mathscr{P}(\mathrm{I})$ of I is used in formula (1), because certain modal words may be associated with more than one degree of intensity of a given modality.

Set R is responsible for referring to the host of the given infon, who can primarily be the speaker (MY) or the hearer (YR: 'your'). That is, the possible-world-like (but finite) basis of interpretation (1), called a "worldlet" in ℜeALIS [13], can be the conglomerate of "my faint conjectures" or "your strong desires", and so on.

Set T adds "temporal stamps" to worldlets, expressing in which period it holds that a given infon belongs to a given worldlet in someone's mind (to the one, for instance, that stores someone's faint conjectures).

Worldlets are also assigned polarity values, which are members of the eight-element powerset $\mathscr{P}(\{+,-,0\})$ of the two traditional polarity values "true" (+) and "false" (–) and a not so accustomed value "non-specified" (see the category "unknown" in [69]). The crucial importance of the fact that the traditional two-element set of truth values has been extended to an eight-element one is illustrated by the difference between the interpretation of (4a) and (4b). In the latter case what is certain is that the given infon ("Ben is a linguist") is not assigned 0 in Sue's mind; but sentence (4b) does not reveal whether it is true or it is false that Ben is a linguist.

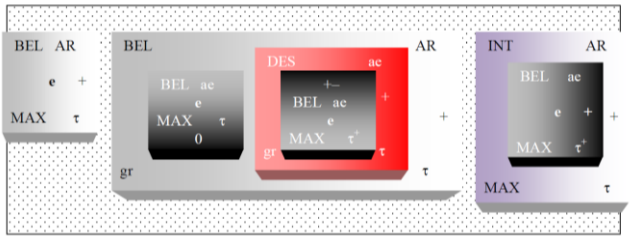
a. "Sue knows that [Ben is a linguist]"
$\langle \mathrm{BEL},\mathrm{MAX},r_{\mathrm{Sue}},\tau,+\rangle$
b. "Sue knows if [Ben is a linguist]"
$\langle \mathrm{BEL},\mathrm{MAX},r_{\mathrm{Sue}},\tau,+-\rangle$
c. "Joe guesses that Sue definitely wants to convince him to take it for granted that [Ben is a linguist]."
$\langle\langle \mathrm{BEL},\mathrm{sm},r_{\mathrm{Joe}},\tau,+\rangle\langle \mathrm{INT},\mathrm{MAX},r_{\mathrm{Sue}},\tau',+\rangle\langle \mathrm{BEL},\mathrm{MAX},r_{\mathrm{Joe}},\tau'',+\rangle\rangle$

Figure 4. Sentences to be interpreted in different world(let)s.

The Kleene-star in formula (1) manifests the "reciprocal" character of ℜeALIS by offering, instead of quintuples of the above-discussed labels, finite series of such quintuples. The series shown in (4c), for instance, points to a special segment of Joe's mind: namely, to the worldlet containing Joe's hypotheses on Sue's intentions towards exactly on his would-be information state.

Finally, the power set symbol in the initial position of formula (1) requires some explanation. The point is that an infon (a piece of information) can be simultaneously associated with more series of worldlet labels (in the human mind). The reference to a "prism effect" in (1) expresses this viewpoint.

The content of the components in Fig. 5, for instance, applied to the Hungarian declarative sentence in (5a), is as follows, from left to right: "(5b) I, (the addresser: AR) know that Péter moved to Mari (I refrain from telling lies or bluffing). (5c) I think that you (the addressee: ae) do not know this. (5d) I think that you would like to be aware of this fact at a later point τ^+ in time (otherwise, I would not have uttered the sentence, since it is important for me to be relevant). (5e) (Being also cooperative) I intend to help you to acquire the infon in question." This analysis is based on the Gricean maxims of conversation [70]; further details are available in our following papers: [5] [3]. The visual representation is essentially a conglomerate of (S)DRT boxes, but, instead of parts of segmented logical formulas, it is immediately the referents (constants/variables) contained that are placed in the partially ordered boxes (in the form of Landmanian "pegs" [62] [8]), augmented with the aforementioned level labels.



a. Péter Marihoz költözött.
P. M.Ade move.Past.3Sg
'Péter moved to Mari's.'
b. ⟨B,M,AR,τ,+⟩
c. ⟨B,gr,AR,τ,+⟩⟨B,M,ae,τ,0⟩
d. ⟨B,gr,AR,τ,+⟩⟨D,M,ae,τ,+⟩⟨B,M,ae,τ^+,+–⟩
e. ⟨I,gr,AR,τ,+⟩⟨B,M,AR,τ^+,+⟩

Figure 5. The intensional profile of the Hungarian declarative sentence.

The conglomerate of the four components in (6b-e) and in Fig. 6 is the intensional profile of the simplest type of yes/no questions in Hungarian, as is proposed in [6] and [3]. Its specific content can be formulated in English as follows, compared to that of the declarative sentence. "1. Now it is me, the addresser, who does not know if Péter moved to Mari. 2. I think, however, that you know the truth. 3. I wish I also knew the truth. 4. (That is why I have started the conversation) I intend to help you to intend to help me to acquire the infon in question."

The circled fifth component presents the pragmatico-semantic contribution of the discourse particle *ugye* (see also the level label given in (6f)). Its contribution can be defined by simply adding a single component to the four-component representation of the yes/no question, which is responsible for expressing the speaker's bias towards the positive answer: "I consider it likely that Péter called Mari." Note in passing that it is no contradiction that the speaker conveys that (s)he is not absolutely sure that Péter moved to Mari (6b) but, at the same time, (s)he considers it quite likely (6f). In our approach, as was mentioned, different levels of knowledge (BEL/MAX vs. BEL/gr) can be considered, and can also be evaluated separately.

Our analysis of the discourse particle *vajon* [3] is based on the observations of Gärtner and Gyuris [71] and Schirm [72] that this special grammatical clue expresses "speculation", "hesitation", "uncertainty", "curiosity", and "reflection". Its meaning—or rather, its pragmatico-semantic contribution—can be revealed by comparing its intensional profile to the intensional profile given in (6b-e), which shows differences in two components out of the four.

The content of the components in Fig. 6.II can be paraphrased as follows: "1. I do not know if Péter moved to Mari's. 2. *I consider it likely* (*unfortunately*) that you do not know the truth either. 3. I wish I knew the truth. 4. (Why have I started the conversation, anyway?) I want you to know that I intend to acquire the given infon."

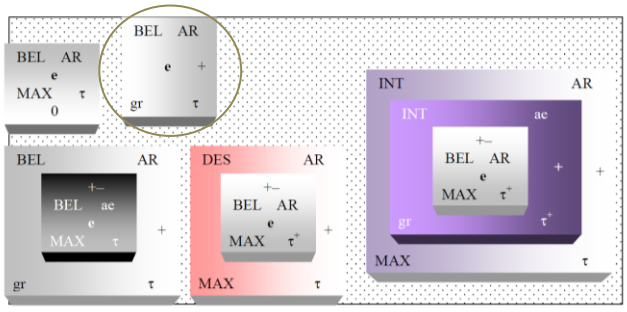


Figure 6.I ↑
a. Péter Marihoz költözött? a'. Péter *ugye* Marihoz költözött?
P. M.Ade move.Past.3Sg P. *ugye* M.Ade move.Past.3Sg
'Did Péter move to Mari's?' 'Péter moved to Mari's, did not he?'
b. ⟨B,M,AR,τ,0⟩
c. ⟨B,gr,AR,τ,+⟩⟨B,M,ae,τ,+–⟩
d. ⟨D,M,AR,τ,+⟩⟨B,M,AR,τ^+,+–⟩
e. ⟨I,M,AR,τ,+⟩⟨I,gr,ae,τ^+,+⟩⟨B,M,AR,τ^{++},+–⟩
f. *ugye*: ⟨B,gr,AR,τ,+⟩

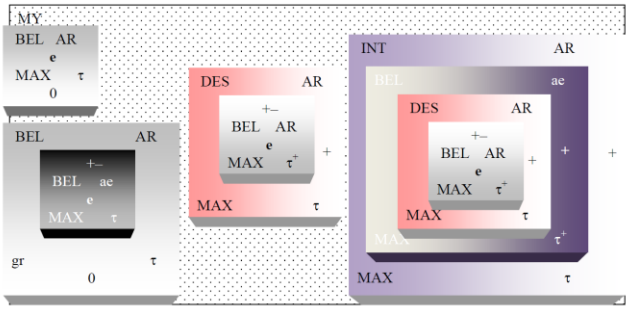


Figure 6.II ↑
g. Péter *vajon* Marihoz költözött?
P. *vajon* M.Ade move.Past.3Sg
cca. 'I would like to know whether Péter has moved to Mari's.'
Intensional profile of (6g): (6b) + (6d) + (6g') + (6g")
g'. ⟨B,gr,AR,τ,+⟩⟨B,M,ae,τ,0⟩
g". ⟨I,M,AR,τ,+⟩⟨B,M,ae,τ,+⟩ ⟨D,M,AR,τ,+⟩⟨B,M,AR,τ^+,+–⟩

Figure 6. The intensional profile of the basic Hungarian yes/no question type in 6.I and (6a), and that of its variants containing the discourse particles *ugye* (see I. and (6a'-f)) and *vajon* (see 6.II and (6g-g")).

Components 1 and 3 are common: the addresser, who does not know if a certain infon is true or false, longs for this knowledge. Components 2 and 4 are new. The addresser does not really hope that the addressee knows the answer; (s)he is only thinking aloud, with no immediate purpose. The only realistic purpose for him/her may be to make the addressee know that (s)he needs the answer.

It is worth addressing the division of labor between pragmatics and semantics. We can separate the at-issue meaning (coming from the original question) and the additional meaning (coming from the discourse particles). *Ugye* and *vajon*, discussed (briefly) above, bear the properties of conventional implicatures [73] [74], namely: semantic (lexical), independent (from at-issue content), secondary (supporting content—"fine-tuning"), not

backgrounded (not part of the common ground), not deniable, and invariably speaker-oriented. In both cases, the at-issue meaning denotes whether Péter moved to Mari's or not. As for *ugye*, the conventional implicature expresses bias toward the positive answer ("I consider it likely that Péter moved to Mari's,"; and as for *vajon*, the implicature translates (roughly) as "I wonder...".

As is illustrated in Figures 5 and 6, thus, picking out the sentence type can be regarded as a "basic settlement" of the intensional profile, relative to which discourse particles are responsible for "fine-tuning" it—as well as such further grammatical elements as epistemic modals [15] [45] [47], evidentials [24] [38], miratives [40], special stress patterns, and Austin's [23] expositive verbs as they are construed in Oishi's approach [24]. The following section is devoted to the illustration of these grammatical clues and their pragmatico-semantic contribution to intensional profiles in the ℜeALIS framework.

IV. The ℜeALIS Pragmatics

First of all, let us overview the requirements towards an up-to-date comprehensive pragmatics on the basis of a current paper by Labinaz and Sbisá [38], who argue that we need to go back to Austin's [23] [36] and Searl's [75] [76] speech act theory in order to provide a framework in which all the elements highlighted by the current accounts can be collected and coordinated.

A. Towards a More Comprehensive Speech-Act Theoretical View

According to Austin [23], every speech act comprises three distinct acts: the act of saying something (the locutionary act), what one does in saying it (the illocutionary act) and what one does by saying it (the perlocutionary act). Acts such as assertions, claims, guesses are illocutionary acts and have distinct, albeit related, illocutionary forces. It is worth picking up the idea that illocutionary acts can be described as the performance of a socially accepted procedure, and that this procedure is to lead to a "conventional" effect. Here are some of the elements that a procedure of such a kind should comprise: (i) kind of person that can execute the procedure; (ii) circumstances in which it is appropriate to execute the procedure; (iii) linguistic forms to be used in order to execute the procedure or make it recognizable; (iv) effects of the procedure on the deontic statuses of the participants; (v) appropriate psychological states of the participants; (vi) appropriate subsequent behavior of the participants, to which they are committed by the procedure executed.

B. Another Speech-Act Theoretical View with the Same Aims

Oishi [24] also intends to revisit and develop Austin's speech act theory, to put forward the idea that expositive verbs bring about effects on the on-going discourse, and that evidentials and epistemic modals play discursive functions by indicating those acts. She argues that to indicate (i) the information source of a thing, event, or situation by an evidential, and (ii) the speaker's epistemic attitude toward it by an epistemic modal is to indicate what illocutionary act the utterance performs. Especially, evidentials and epistemic modals indicate a particular type of expositive illocutionary act, which is one of Austin's categories of illocutionary acts. We intend to complete this list of indicators with miratives (e.g., *gee* in English and its Hungarian counterpart *jé*) and with special stress patterns, beyond the choice of the sentence type itself; see Subsection IV-C.

Oishi [24] argues that in performing one of the various types of expositive act, the speaker expounds her/his communicative engagement with the hearer, while inviting him to react to it in a specific way. There are various types of communicative activities that the speaker can provide: in saying an utterance, the speaker does something with a thing/event/situation in the world, with a statement, with the hearer, with knowledge about a thing/event/situation in the world, with the statement that has been imported, and/or with a thought.

All this can be captured in the theory proposed by Oishi [24] in a surprisingly simple way: in the case of each speech act, the speaker is to be distinguished from the addresser of the act, and the hearer from the addressee of the act, and the situation from the context of the act. The dynamism of performing the illocutionary act and the corresponding perlocutionary act, thus, is explained as complex interrelations between the speaker and the addresser, the hearer and the addressee, and the situation and the context.

C. Checking The Complex Pragmatic Interrelations via Generalized Truth-Conditional Evaluation in ℜeALIS

We claim that checking all elements of the aforementioned complex interrelations, as well as the similar ones listed in Subsection IV-A as (i-vi), essentially boil down to the evaluation of truth values over the ℜeALIS universe, defined in Section III, due to the simultaneous presence in a single model of the external world and all of its mind-internal (finite) alternatives; see Fig. 1 in Section II.

As for checking, for instance, whether the particular speaker and the particular hearer are suitable for playing the roles of the addresser and the addressee in the case of certain speech acts, a finite set of external relations must be checked even in the world's most complicated system of speech levels and honorifics in Korean; see Table I.

The plain level, for instance, is used typically by any speaker to any child, to his own younger sibling, child, or grandchild regardless of age, or to one's daughter-in-law, or between intimate adult friends whose friendship started in childhood. The intimate level is used by a child of pre-school age to his or her family members including parents, or between close friends whose friendship began in childhood or adolescence. It may also be used to one's adult or adolescent student, or to one's son-in-law. The familiar level is slightly more formal than the intimate level, typically used by a male adult to an adolescent such as a high school or college student or to one's son-in-law, or between two close adult friends whose friendship began in adolescence. The remaining three levels are used only to adult hearers.

Table I. Honorification in Korean [77] [78]

Clause type/speech level	Declarative	Interrogative	Imperative	Propositive
Plain	*po-n-ta* see-IND-DECL	*po-ni* see-Q	*po-a-la* see-INF-IMPV	*po-ca* see-PROPOS
Intimate	*po-a* see-INF			
Familiar	*po-ney* see-DECL	*po-na* see-Q	*po-key* see-IMPV	*po-sey* see-PROPOS
Blunt	*po-o* see-BLUNT			—
Polite	*po-a-yo* see-INF-POLITE			
Deferential	*po-p-ni-ta* see-ADD.HON-IND-DECL	*po-p-ni-kka* see-ADD.HON-IND-Q	*po-si-p-si-o* see-SUBJ.HON-ADD.HON-REQUEST-IMPV	*po-p-si-ta* see-ADD.HON-REQUEST-PROPOS
Neutral	*po-n-ta* see-IND-DECL	*po-n-unya* see-IND-Q	*po-la* see-IMPV	*po-ca* see-PROPOS

Probably the most popular level is the polite level, which is the informal counterpart of the deferential level. While deferential level is usually used by males, the polite level is used widely by both males and females in daily conversations. Both the polite and the deferential levels are used to a socially equal or superior person, but in general, the polite level is favored between close persons. It is also worth mentioning that no propositive form is available in the superpolite level, presumably due to the fact that the addressee must be so vastly superior when using this level that the speaker could not propose to share an action; and so on.

The details are irrelevant here. What is relevant is that however intricate this system is, capturing the interrelations is nothing more than a typical programming task for ambitious Prolog beginners.

Checking whether a situation is a suitable context for a particular expository speech act, predominantly requires the pattern matching techniques developed in (S)DRT [22], underlying ℜeALIS. Antecedents of pronouns and definite noun phrases are to be sought either in certain worldlets in certain minds (in the course of anaphora resolution) or in the external-world model (in the case of deixis). Setting up rhetorical relations between a new infon and a salient infon in the context also belongs to the task discussed in this paragraph; this is exactly the specialty of SDRT [71] [26].

We conclude this section by noting that what Oishi [24] must consider a crucial difference between expositive acts and the other four classes of illocutionary acts proposed by Austin [23] is no difference in ℜeALIS, in an advantageous way. "They are not changes in the world ... or changes in the social world ... In the expositive act, the speaker and the hearer are assumed to be discourse participants who sustain and develop the discourse. By performing this type of act, the speaker tries to control the discourse [and not the world] and influence the hearer as a discourse participant." In ℜeALIS, the internal contents of human minds are defined as parts of the world—as they are, indeed.

D. Linguistic Clues in Hungarian Sentences and Intensional Profiles

It is high time to exemplify the linguistic elements that contribute to the decision of the speech act, that is, essentially, to that of the intensional profile, in some way or another, as was promised in the last paragraph of Section III. Note that the annotations follow the conventions used in the series *Approaches to Hungarian* (Amsterdam: Benjamins).

The (a) sentence in Fig. 7 is ambiguous due to the modal suffix in italics (*-hAt*). The epistemic (a') interpretation differs from the deontic (a") interpretation in two crucial points [15]. While in the latter case the addresser commits her-/himself to the truth of the infon carrying the piece of information that Péter moved to Mari ('B^M' refers to 'maximal belief', that is, to certain knowledge), in the former case (s)he has only "some certainty". The other difference is that according to the deontic interpretation there is a person r* whose intention it depends on whether Péter can move to Mari. It is asserted in the case in question that r*'s intention towards the move is neutral ('0'), and not positive or negative; r*, thus, permits the move in question, by withholding his intention. In the case of the epistemic interpretation, what the addresser does not intend ('$\langle$I,M,AR,τ,0$\rangle$') is to prevent the addressee from conjecturing ('$\langle$B,sm,ae,τ^{+},+$\rangle$') that Péter moved to Mari.

Sentence (7b) is also a conjecture expressing the addresser's epistemic uncertainty (7b'), but its meaning has an interesting evidential component (7b"): it is implied that the addresser probably saw the action in question.

Sentence (7c) exemplifies a mirative marker, whose peculiar meaning contribution is that the addresser accepts the given infon (7c'), which is new to her or him (7c''), and somewhat surprising (7c''').

a. Péter Marihoz költöz*het*ett.
P. M.Ade move.may.Past.3Sg
'Péter may have moved to Mari's.' 'Péter was allowed to move to Mari's.'
a'. ⟨B,sm,AR,τ,+⟩ a''. ⟨B,M,AR,τ,+⟩
⟨I,M,AR,τ,0⟩⟨B,sm,ae,τ+,+⟩ ⟨I,M,r*,τ,0⟩

b. Péter *mintha* Marihoz költözött *volna*.
P. as_if M.Ade move.Past.3Sg be.Cond.3Sg
'Péter may have moved to Mari's. I may have met them—but I cannot remember.'
b'. ⟨B,sm,AR,τ,+⟩ b''. ⟨SAW,sm,AR,τ,+⟩

c. *Jé*, Péter Marihoz költözött! d. Péter *persze* Marihoz költözött.
Gee P. M.Ade move.Past.3Sg P. of_course M.Ade move.Past.3Sg
'Gee, Péter moved to Mari's.' 'Péter moved to Mari's, of course.'
c'. ⟨B,M,AR,τ,+⟩ d'. ⟨B,M,AR,τ,+⟩
c''. ⟨B,M,AR,τ⁻,0⟩ d''. ⟨B,aM,AR,τ,+⟩⟨B,gr,ae,τ⁻,+⟩
c'''. ⟨D,sm,AR,τ,+–⟩

Figure 7. Markers of epistemic and deontic modality, and evidential and mirative markers in Hungarian

The discourse particle *persze* (cca. 'of course') is used in contexts when speaker and listener share or are supposed to share common knowledge [80]. We claim that it corresponds to the Latin *scilicet*, which "indicates that the evidence is based on expectation ('as is to be expected,' 'of course') and is strongly directed towards the addressee, [in contrast to, say] *videlicet* [which] indicates that the evidence is inferable from the context or reasoning ('clearly') and is not directed towards the addressee" [81]. This special meaning component is captured by the level label presented in (8d'') via referring to an information state of the addressee that precedes the utterance time (τ^-); it is expressed in this way that the addressee could have been almost sure that Péter had moved to Mari without having been informed about that. That is, this almost certain piece of knowledge is not due to any inference drawn on the basis of what has been said by the addresser, but rests upon the given addressee's peculiar knowledge.

Now we provide a comparative overview of different Hungarian sentence types with imperative verb morphology given in (8a-f), whose intensional profiles are presented in the table. Our pragmatico-semantic analyses are chiefly based on Szücs's empirical observations and systematization [82] but other results are also considered [71] [83].

a. Költözzön Péter Marihoz! b. *Kööötöl*tözzön Péter Marihoz!
move.Imp.3Sg P. M.Ade *move*.Imp.3Sg P. M.Ade
'Péter should move to Mari's.' 'Péter can move to Mari's, I do not mind.'

a'. ??Költözzek Marihoz! b'. ??*Kööötöl*tözzek Marihoz!
move.Imp.1Sg M.Ade move.Imp.1Sg. M.Ade
'Let Péter move to Mari's.' 'Let me move to Mari's.'

c. Hadd költözzön Péter Marihoz! c'. Hadd költözzek Marihoz!
let move.Imp.3Sg P. M.Ade let move.Imp.1Sg. M.Ade
'Let Péter move to Mari's.' 'Let me move to Mari's.'

d. [Hadd pletykáljanak]$_e$, [odaköltözöm Marihoz]$_{e'}$!
let gossip.Imp.3Pl there.move.1Sg Mari.Ade
'Let there be gossip, I do not mind, I will move to Mari's.'

e . Költözzön *csak* Péter Marihoz! f. Költözzön *már* Péter Marihoz!
move.Imp.3Sg only P. M.Ade move.Imp.3Sg already P. M.Ade
'Let Péter move to Mari's.' 'I want Péter to decide to move to Mari's at long last.'

Figure 8. The intensional profiles of some Hungarian sentence types with imperative verb morphology (see also Table II)

It is common in all types (see the first two rows of Table II) that the addresser of the chosen speech act is sure that the result phase $\varphi_{res}(e)$ [65] of the given eventuality e does not hold (i.e., Péter and Mari still live in different flats, that is, Péter has not moved to Mari yet) and more or less assumes that the addressee is also aware of this fact (the certainty of her or his assumption is given as 'nM', that is, 'non-maximal').

By performing the basic imperative type (8a), the addresser longs for the aforementioned result state $\varphi_{res}(e)$ and wants the addressee to intend the action e. The addressee's stimulated intention is optimally efficient if (s)he coincides with the agent of the action ("Move to Mari's."). It is, however, definitely excluded that the addresser and the Agent coincide (8a') [84]. Note that (8a) is the only imperative in the strict sense proposed in [71], (8b-f) can rather be classified as proto-imperatives.

Table II. Imperatives and Proto-Imperatives in Hungarian

	a. Basic	b. CVVVC...	c. *hadd*$_1$	d. *hadd*$_2$	e. *csak*	f. *már*
AR's knowledge conc. $\varphi_{res}(e)$	⟨B,M,AR,τ,–⟩	←	←	←	←	←
ae's knowledge conc. $\varphi_{res}(e)$ (acc. to AR)	⟨B,nM,AR,τ,+⟩ ⟨B,M,ae,τ,–⟩	←	←	←	←	←
AR's, ae's and/or Ag's desire conc. $\varphi_{res}(e)$	⟨D,M,AR,τ,+⟩	⟨D,M,AR,τ,0–⟩	⟨D,M,AR,τ,0+⟩	*hadd*$_2$ ←, but for e'	⟨D,nM,AR,τ,–⟩	⟨D,M,AR,τ,0+⟩
		⟨B,nM,AR,τ,+⟩ ⟨D,M,r*,τ,+⟩	⟨B,nM,AR,τ,+⟩ ⟨D,M,ae,τ,0–⟩	For e: ⟨B,nM,AR,τ,+⟩ ⟨D,M,r*,τ,0–⟩	⟨B,nM,AR,τ,+⟩ ⟨D,M,r*,τ,+⟩	⟨B,nM,AR,τ,+⟩ ⟨D,M,r*,τ,+⟩
			⟨B,nM,AR,τ,+⟩ ⟨D,M,r*,τ,+⟩	⟨D,M,AR,τ,0+⟩ ⟨D,s,AR,τ,–⟩		⟨D,M,AR,τ,+⟩ ⟨I,M,r*,τ,+⟩
AR's intention conc. e and/or ae's intention	⟨I,M,AR,τ,+⟩ ⟨I,M,ae,τ+,+⟩	⟨I,sm,AR,τ,0⟩ ⟨I,M,AR,τ,–⟩ ⟨I,M,ae,τ+,–⟩	⟨I,M,AR,τ,–⟩ ⟨I,M,ae,τ+,–⟩	⟨I,M,AR,τ,+⟩	⟨I,M,AR,τ,0–⟩ ⟨I,M,ae,τ+,–⟩	⟨I,M,AR,τ,+⟩ ⟨I,M,ae,τ+,+⟩ ⟨I,M,r*,τ++,+⟩
Note	Ideal: ae = Ag	Preferred: r*= [ae > Ag]	c'. Preferred: AR = r*	Preferred: r*=ae	Preferred: r*= [Ag > ae]	Preferred: r*= [Ag > ae]
	Excluded: AR = Ag	Pref'd/Excluded: r*= ae = Ag ≠ AR	Excluded: ae = Ag			Pref'd/Excluded: ae = Ag ≠ AR

Type (8b) differs from the basic type only in intoning the first syllable of the verb stem in a peculiarly lengthened way. The effect is that now it is not the addresser who longs for the given action but the addressee or the agent of the action. As for intentions, the addresser remains neutral, and does not want the addressee to do anything against e. It is, again, definitely excluded that the addresser and the Agent coincide (8b').

Type (8c) is associated with a third "distribution" of intentions among the three straightforwardly interested participants: the addresser, the addressee and the agent of the action in question. Now it is the addressee who is assumed not to long for $\varphi_{res}(e)$ while the addresser and the Agent long for it. The latter two participants preferably coincide (8c') while this time it is the coincidence of the addressee and the Agent that is excluded.

In the speech act defined by (8e), the addresser is definitely against $\varphi_{res}(e)$, which is now assumed to be longed for very much by the agent (or, perhaps, the addressee). (8f) presents a new distribution of intentions again: the addresser thinks that someone, preferably the agent, longs for $\varphi_{res}(e)$ very much, and (hence) wants this person to realize her or his wishes.

Instead of entering into further details, which obviously does not belong to the aims of this paper, we would like to call the reader's attention to the following generalization: checking whether the speaker, the hearer and the given situation are suitable for serving as the addresser, the addressee and the context of the linguistically defined speech act (à la Oishi [24], see Section IV-B) simply requires a truth-conditional investigation primarily into the addresser's mind's certain worldlets (e.g., what (s)he longs for and assumes certain other persons to long for). The task boils down to get to the worldlets in which certain polarity values must then be checked.

Let us now suppose that a speaker performs (9a), which is the same as (8b), while thinking what is described in (9b). As now all the beliefs, desires and intentions are compatible with the speech act determined by the imperative sentence type and the peculiar intonation, the speaker proves to be impeccably sincere while performing (9a). She or he is undoubtedly suitable for playing the addresser's role in the speech act (s)he has initiated.

a. Speaker: "*Kööölt*özzön Péter Marihoz!"

b. Facts $\prec$ beliefs: $\langle B,M,MY,\tau,-\rangle$; $\langle B,M,YR,\tau,-\rangle$;
$\prec$ desires: $\langle D,sm,MY,\tau,-\rangle$; $\langle D,sm,YR,\tau,+\rangle$; $\langle D,sm,r_{Péter},\tau,+\rangle$;
$\prec$ intentions: $\langle I,sm,MY,\tau,0\rangle$; $\langle I,sm,YR,\tau^{+},+\rangle$

c. Facts $\prec$ beliefs: $\langle B,M,MY,\tau,0\rangle$; $\langle B,M,YR,\tau,+\rangle$;

c'. Facts$\prec$desires: $\langle B,M,MY,\tau,+\rangle\langle D,M,YR,\tau,0\rangle$; $\langle B,M,MY,\tau,+\rangle\langle D,M, r_{Péter},\tau,-\rangle$

Figure 9. Ideal matching between interlocutors and speech act participants, and mistake or deception in matching

Let us now suppose, however, that the relevant facts are as in (9c). That is, the speaker does not know whether Péter lives together with Mari, and the hearer definitely knows that they already have lived together. In a case like this, the speaker was insincere due to her or his bluff, by which (s)he pretends as if (s)he were sure that Péter had not moved to Mari yet. As for the hearer, it would be pertinent to inform the speaker about the (supposed) mistake according to which Péter and Mari still live in different flats. It is in this way that the hearer should get rid of the incompatibility between the speaker's declared presupposition and the real facts in the world.

If the speaker thinks as follows while performing (9a): "you do not bother whether Péter moves to Mari or not, and Péter wants to definitely refrain from moving to Mari," the utterance contains insincerity and/or hypocriticality. The speaker wants to deceit the hearer in respect of her or his knowledge on the hearer's and Péter's wishes.

The intricate phenomena of politeness can also be captured on the basis of the triplets of the readily comparable intensional profiles of the utterance, of the addresser and of the addressee in ℜeALIS (the theory) and by means of ℜeALIS2.1 (the software application). As is illustrated in Fig. 10, the addressee her- or himself must consider two intensional profiles simultaneously in order to be capable of correctly decoding the addresser's real intention. Utterance (10a) is itself ambiguous (10b-c), but it is also worth taking potential ulterior motives into account (10d). The addressee, thus, needs to continuously set up hypotheses during the on-going discourse in the form of intensional profiles, which are worth being compared to the linguistically encoded intensional profiles that belong to the clauses performed by the addresser.

a. Főznél egy levest?
Cond.2Sg a soup.Acc
b. literal meaning: 'Do you want / [feel like] to cook a soup?'
c. request: 'Cook a soup, please.'
d. Suppose the sentence is used in a situation in which the addressee has been telling a story to a group of people, which is unpleasant to the addresser; the addresser intends to interrupt the addressee by this seeming request (or inquiry), in the hope that (s)he forgets to continue the unpleasant story.

Figure 10. Literal meaning, politeness or ulterior motives?

In the particular case, thus, the hearer needs to decide on the basis of her of his own intensional profile about the speaker's beliefs, desires and intentions whether (s)he is really interested in the addressee's wishes (10b), or longs for a good soup (10c), or both hypotheses mentioned can be excluded and/or ulterior motives can me assumed. Observe that checking all these hypotheses can be modeled in ℜeALIS as evaluating polarity values in appropriate worldlets in worldlet-based representations of human minds.

Note in passing that certain polite forms do not yield ambiguity. The form presented in (11c), for instance, used typically by young people to old people, chiefly to old ladies, has no any kind of literal meaning. It is conventionalized in such a way that is to be regarded as an unambiguous expression of a certain speech act.

a. Láttad? b. Látta? c. Tetszett látni?
see.Past.2Sg see.Past.3Sg like Past.3Sg see.Inf
'Have you$_{Sg}$. seen it?'

Figure 11. Degrees of politeness in Hungarian

The type illustrated in (11b), however, is ambiguous between a "literal meaning" with a 3Sg. subject ('Have (s)he seen it?') and a polite interpretation in which the subject is the addressee.

V. USERS AND USES

ℜeALIS1.1 (just like ℜeALIS2.1) is worth demonstrating as a software application intended to supply collaborating linguists and certain types of non-linguist experts, because in this way it is quite easy to capture, at the same time, the required input data types and the output production.

A. Internal Users

Our software application ℜeALIS1.1 is primarily intended to supply linguists with a device to build fragments of arbitrary languages of arbitrary morphological types (NB: it is worth elaborating applications based on Hungarian since this language is an ideal challenge due to its extremely rich morphology [18] [20] [55]). These fragments can capture such specialties of human languages as, for instance, the compositional cumulation of meaning units [25]. The definable meanings are pragmatico-semantic descriptions that satisfy the relevant definitions of ℜeALIS. The group of users defined in Section V-A will be referred to as internal users.

B. External Users

Those using the developed language fragment will be referred to as external users. In the course of using the software application, they can select lexical items to build sentences, the (generalized) truth-conditional interpretation of which they will be given on the basis of a "multiplied world model", which they have themselves constructed or received from "internal" experts [12].

Possible external users may be detectives or judges, for instance, who can have the truth of groups of propositions evaluated. In harmony with our "constructionist" stance, we mean by the aforementioned "generalized truth-conditional evaluation", besides the final *true/false* value, the collection of all the information required to reach this truth value. Our software application thus, among others, serves the purpose of collecting and systematizing data in the effective structure that ℜeALIS offers. ℜeALIS2.1 offers an even more extended truth-conditional evaluation, which pertains to all the pragmatic aspects discussed in Section IV. It is checked, thus, whether the speaker, the hearer and the given situation are suitable for serving as the addresser, the addressee and the context of the linguistically defined speech act, on the basis of the model of the external world and its human-mind-internal images called worldlets in ℜeALIS (Section IV-D).

C. Defining Relations

Internal users can define an external world w_0, over the universe of which (consisting of entities u_i) they can define relations of different arities [25]. One argument of all these relations is to be a series of disjoint temporal intervals. The program is to "dictate" (through permanent queries) the development of the external world: it requests new and new relations, and in the case of a given relation it requests the provision of (the initial and final points of) temporal intervals (among others).

Such relations can be defined in this way that are homogeneous in the sense that they qualify as true or false "momentarily", i.e., at each internal point of the temporal intervals independently. In Hungarian, for instance, *utazik* 'travel' and *úszik* 'swim' are homogeneous relations while *hazautazik* 'travel home' and *átússza* 'swim across' are heterogeneous. Further, each argument position of a relation can be associated with other relations of the group of relations defined earlier that provide us with restricting information. The agent argument of the Hungarian verb *utazik* 'travel', for instance, can be associated with the restricting relation *ember* 'human'.

D. Defining Label Strings of Worldlets

Relative to the set of "worldlets" (small partial models of alternative worlds) defined up to a certain point, the internal user can define (by simultaneous recursion) a new worldlet where the basis of this definition is the singleton consisting of the external world w_0. Specifically, relative to a worldlet w', a worldlet w" can be determined through a quintuple of labels like the one shown in (12a). Recall that it defines the worldlet containing a human being's (r_{Sue}) knowledge ("maximal" belief); see sentence (2b) in Section II and (4a) in Section III.

a. $\langle \text{BEL,MAX,r}_{\text{Sue}},\tau'',+\rangle$
b. $\varnothing$ / + / – / 0 / 0– / 0+ /+– / 0+–
c. $\langle\langle \text{BEL,sm,r}_{\text{Joe}},\tau,+\rangle\langle \text{INT,MAX,r}_{\text{Sue}},\tau',+\rangle\langle \text{BEL,MAX,r}_{\text{Joe}},\tau'',+\rangle\rangle$

Figure 12. Labeling worldlets.

Alternatives to label BEL are labels INT (intention) and DES (desire), among others. Alternatives to label MAX are lower levels of intensity: e.g., aM (almost maximal). The fourth member of the label quintuple is polarity; the values of this parameter are listed in (12b), on the basis of formula (1) in Section III.

The software application can show through what kind of defining steps one can reach a worldlet relative to the external world as a fixed starting point. The label string in (12c), for instance, defines a worldlet that is to be regarded as the collection of information the status of which can be captured, for instance, by means of the linguistic expression shown in (2c) in Section II: "Joe guesses that Sue definitely wants to convince him to take it for granted that [...]." The worldlet where we should get, thus, is inside Joe's mind, immediately embedded in a worldlet containing thoughts that Joe attributes to Sue. The label of the worldlet in question expresses that it consists of Sue's assumed intentions towards exactly Joe himself.

E. Worldlets, Infons and Polarity Values

Internal users can assign pieces of information to worldlets. This procedure is to be "dictated" by the program as follows.

In the more general case, a point in time must be specified. As a reaction of the program, on the basis of the above-discussed temporal-interval series belonging to the relations, it is written which relations stand between which entities at the given point of time. If the user specifies,

besides a point in time, a relation and some entities that occupy certain argument positions of the relation, the task of the program remains the writing of the lacking entities that stand in the given relation with the provided entities at the provided point in time. The unit of this writing process is the external infon [61]: an infon means the piece of information that certain entities stand in a certain relation at the given moment (e.g., Joe loves Sue, or Joe is just traveling).

Internal users can assign an infon (produced in the way sketched above) to an arbitrary worldlet for an arbitrary temporal interval. The application of this temporal interval serves the purpose of capturing such factors as the dwindling into oblivion or some re-categorization of pieces of information.

Assigning a group E of infons to a worldlet standing with the external world in the relation provided in (13a) can be interpreted as follows: Sue perceives information E from the external world and accepts as the current state of her environment. A similar interpretation in the case of the complex relation provided in (12c) is as follows: Joe suspects that Sue wants to make him to be sure that information E is true (while Sue herself, for instance, does not necessarily believe in the truth of E; nor is E true in the external world).

If the same infon is simultaneously assigned to someone's positive belief-worldlet (see '+' in (12b)), negative desire-worldlet ('–') and neutral ('0') intention-worldlet, this complex "evaluation" captures this typical situation: the person in question perceives something and accepts its truth, but longs for its opposite without intending to change it (at least at that moment).

It is worth noting in connection with the polarity values listed in (12b) that if an entity does not stand in the relation 'be a linguist' in the external world, then the infon declaring the given entity's momentary being a linguist is to be assigned to the experiencer's negative ('–') or 'undefined' ('∅') belief-worldlets depending on the restricting relations, mentioned in Section VI-A. Ben, for instance, can be thought by an experiencer to be "not a linguist" while in the case of the Eiffel Tower, its being a linguist is undefined.

As for the combination +– in (12b), see (4b) in Section III, together with the relevant comments there. Further uses of the polarity-value combinations are exemplified in (5d), (6c-e), (7c'''), (8b-f) in the previous sections.

F. Information Not Coming from Outside

Internal users can also assign information to worldlets indirectly, that is, not on the basis of (the relations of) the external world. This is "dictated" by the program as follows.

The program asks for predicate names and argument numbers, and then produce argument places with inserted "new" entities, which the software must also urge the user to anchor to "old" (external or internal) entities (NB: their anchoring to any entities is only a possibility). Section V-E, where we defined the procedure of creating infons assigned to worldlets in human minds on the basis of states of affairs in the external world, is worth completing with a short comment. An internal infon does not contain the same entity names as the corresponding external infon does. Instead of identifying them, the correspondence between external and internal entities is accounted for by (α-) anchoring elements of the former group to those of the latter group. In this way, we can explain the cases of misunderstanding where the same external fact is linked to different participants in two experiencers' minds (see the definition of ℜeALIS in Section III).

G. Building the Lexicon

The internal user is given a core lexicon on the basis of the predicates the creation of which was described in Section VI-C; and this core lexicon is enriched with the predicates created in the way described in Section VI-D. Elements of the latter group of predicates must be associated with meaning postulates [25], by the help of queries of the program.

Note that items of the core lexicon need not be associated with meaning postulates since their interpretation is trivial on the basis of their creation: as they have been created by copying certain "patterns" of the external world, the rule concerning the pattern matching their semantic evaluation is based on is automatic. True perception and pattern matching is the same process, considered from opposite directions (cf. Searl's world-to-word and word-to-world directions of fit [75]).

Let us return to the predicates whose forms are defined in Section VI-D; they are assigned meaning in the way to be defined in Section VI-F. Before entering into details, it must be noted that this is the crucial innovation of ℜeALIS1.1, because this is the toolbox which exploits the advantages and results of all the model-theoretic theories, the discourse-representational innovations and the proof-theoretic ideas, and the "diagnosis" of cognitive linguistics on the weaknesses and shortcomings of these three approaches.

What comes from formal semantics [25]? The procedure of pattern matching. Further, the application of interpretational bases used as alternatives to each other ("possible worlds" $\rightarrow$ ℜeALIS-worldlets). And the consideration of the rate of successful instances of pattern matching compared to the entire set of possible instances of pattern matching.

The idea of operation over the partially ordered system of worldlets is due to DRT [21] [22]. The step-by-step execution of this operation, referred to as 'accommodation' in DRT, coincides with the proof-theoretic processing of semantic information [43].

The modeling of the following linguistic elements is basically due to cognitive linguists [48] [85]: *me*, *you*, *(s)he*, *here*, *there*, *now*, *then*, *these here* (in the context), *those there* (demonstration); see also [38].

H. How to Define Lexical Items

The program must help the internal user (the formal linguist) in assigning (groups of alternative) phonetic forms and meaning postulates to predicate names, besides such straightforward information as (sub)categorization and argument number.

Meaning postulates essentially consist of first-order formulas. The most peculiar element of our method is that

each formula like this must be associated with a set of such chains of worldlet labels as the one shown in (12b) and the information as to which worldlet(s) these chains to be linked to in the course of interpreting sentences (possibilities are the external worldlet, certain worldlets of the selected speaker/addresser, hearer/addressee, or participants referred to in the sentences, or worldlets that can be identified in the selected context or scope of demonstration (see the last paragraph in Section V-G).

I. Use Cases for External Users Building the Lexicon

The external users—who can construct a sentence and specify the speaker, the hearer, the entities assumed to be present in the context (and possibly a subset of those in the scope of some demonstration), the speech time and the time of reference, among others—are given a generalized truth evaluation. This means that they are given not only a truth value but also all the pragmatic well-formedness conditions of the sentence "performed" in the specified situation to be construed as the context of a certain speech act.

Thus, they can look "inside" all relevant participants' minds (i.e., the current and possibly some previous information states). They can realize, for instance, whether the definite noun phrases are suitable for unambiguously identifying the intended *denotata*. They can also receive information about the success of satisfying other kinds of presupposition. They can detect, through comparing the information provided by the sentence and the information found in the specified interlocutors' appropriate worldlets, whether there might emerge some misunderstanding, lie, bluff, deception [5], as is expounded in Section IV-D.

VI. LINGUISTIC EXAMPLES

External users are given a peculiarly multiplied data base that contains, besides a relational model of some fragment of (the history of) the external world, several of its alternatives. Recall that these alternatives essentially play the role of possible worlds, known from intensional model-theoretic semantics, but they are finite constructions appearing as such parts of information-state models of interlocutors that can be construed as their beliefs, desires, intentions, or any other kinds of fictions.

A. Generalized Truth Evaluation

The above-sketched arrangement of worldlets enables us to carry out truth evaluation not only on the basis of the external world, which is necessary and sufficient, for instance, in the case of sentences (13a-a'), but also on the basis of internal worldlets, which is obviously necessary in the case of sentences like (13b). The truth of the variants shown in (13b) does not depend on any facts in the external world. It depends on nothing else but Joe's knowledge, or the knowledge that Sue attributes to Joe. In this latter case, it requires more steps to reach the worldlet that can serve as the basis of truth evaluation (external world model → Sue's belief → Sue's hypotheses on Joe's beliefs); cases like this make it necessary to localize worldlets in the recursive way illustrated in (12c) in Section V-D. Verbs expressing modal attitude (e.g., *think*, *guess*, *conjecture*, *wish*) and many other expressions (e.g., *according to someone*) can be associated with meaning postulates by means of the tool described in Section V-G: the essence of their meanings lies with the "direction indicator" function. Such direction indicators help us finding the worldlets that can serve as the basis of the truth evaluation of the proposition that appears in the appropriate argument positions of the modal verbs or other linguistic expressions in question.

a. It was snowing. a'. It has snowed.
b. (Sue thinks that) Joe knows that it was snowing.
c. Patty was traveling home.
d. *That tall Finnish woman* is pretty.

Figure 13. Generalized truth evaluation relying on worldlets.

B. Past Continuous and Present Perfect

Internal users can work out exacting and sophisticated syntaxes and semantics by the help of the toolbox offered by ℜeALIS1.1.

The truth value of (13a), for instance, can be calculated in the following way: the program must query the values of *then* and *there*, and then it localizes the area of the temporal external world model where pattern matching is to be attempted in order to decide whether it is snowing "then" and "there".

The truth evaluation of (13a'), however, requires the values of *here* and *now*, and what is to be checked in the external world is whether the landscape is snowy. The meaning postulate of the verb *snow*, thus, contains the determination of the result state (*snowy*), too, discussed in detail in [65], for instance. Note in passing that (13a') pragmatically suggests that it is not snowing at the relevant moment while the land is snowy as a result of an earlier snowing.

C. Progressive Aspect

The truth evaluation of sentence (13c) also requires a polished and exacting meaning postulation because not only facts of the external world is to be taken into account. A progressive sentence like this is also to be evaluated to be true in a case in which Patty never got home (this observation is called the Imperfective Paradox [86]) but she proves to have been travelling at the moment of *then*, she proves to intend to come home, and the speaker proves to attribute a quite high likelihood to this arrival (Section V-H) [21] [65]. Thus, the content of certain internal worldlets is to be checked, besides the partial satisfaction of a travelling event in the external-world model.

D. The Intensional Character of Nicknames

A demanded pragmatico-semantic analysis of nicknames also requires the toolbox sketched in Section V-H. Who is *Patty* in (13c), for instance? Internal users can capture the essence of the task of finding *denotata* by construing nicknames as special predicates whose "truth evaluation" involves not (only) the external control on the correspondence between official names and nicknames but (also) the worldlets concerned in the following questions: is *Patty* a possible nickname of the speaker for the given person, does the speaker think that the addressee may (also) call her Patty, do they know this about each other, and so on. Hence, internal worldlets are to be checked via pattern matching.

E. (Partially) Subjective Predicates

Example (13d) illustrates further advantages in meaning postulation of the toolbox demonstrated in Section V-H. The adjective *pretty*, for instance, is worth regarding as a fully personal and subjective judgment, with no extension in the external world. Nevertheless, (13d) does not mean exactly the same as the sentence *I consider her pretty*. The truth of this latter sentence exclusively depends on the speaker while it would be elegant to base the evaluation of sentence (13d) on a somewhat less speaker-dependent calculation. As follows, for instance: (13d) is considered true if *most* persons in the external-world model consider the given lady to be pretty. According to an even more elegant solution, instead of the entire set of persons, only those *respected* by the speaker are considered. The extension of the verb *respect* is to be checked in the external-world model, in a way that is essentially the same as checking the appropriate interpersonal relationships in the case of the superpolite Korean interlocutors discussed in connection with Table I in Section IV-C

F. Demonstration and Anchoring

The demonstrative noun phrase in (13d) illustrates another instance of the necessity for "pragmatically conscious" truth evaluation. *That* asks for the value of the "those there" parameter from the external user. It is elegant to assume that this value is a set of entities, out of which the program selects a unique entity on the basis of the predicates *tall*, *Finnish* and *woman*. Their extensions count in the external world, at least primarily; it is an elegant facility, however, to inspect the speaker's beliefs as well, or the speaker's hypothesis about the addressee's beliefs: sentence (13d) can be evaluated as *true but ill-formed* if, for instance, the speaker intends to refer to a tall Swedish woman about whom they think, incorrectly, that she is Finnish.

VII. ℜEALIS1.1, ℜEALIS2.1 AND RUDI

Three software applications are compared with each other in this section.

A. ℜeALIS1.1

The implementation ℜeALIS1.1 is a client-server Windows application that has been elaborated in a Delphi environment, which guarantees rapid and flexible development. Access to data is executed via standard SQL commands by means of a relational data-base management system. For this purpose, we currently use Firebird Interbase.

The Prolog basis, applied in the experimental phase of our research [58] [59] [11], has been replaced with Delphi environment, which is more capable of managing large data-bases, developing user-friendly interfaces, and constructing more complex applications. This is the radical difference between ℜeALIS1.1 and the aforementioned works (NB: the Prolog basis is retained in certain software applications of ours [54] [87]).

The menu items correspond to the services sketched in Section V. Particular menu items are available to the different kinds of users (also defined in Section V) after checking their identity and authenticity. In the course of parsing sentences, morphological input is produced by the procedures demonstrated in [20] [51] [55] , agreement relations are checked by a method similar to the one shown in [88], dependency relations are calculated by means of our special rank parameters [56], and Prim's algorithm is used for producing one or more spanning trees with a minimal cost. At some points, the program provides illustrations of the structures constructed by either the system or its users: for instance, parsing trees, systems of worldlets, and anchoring relations of entities are illustrated. Fig. 14 presents this last facility.

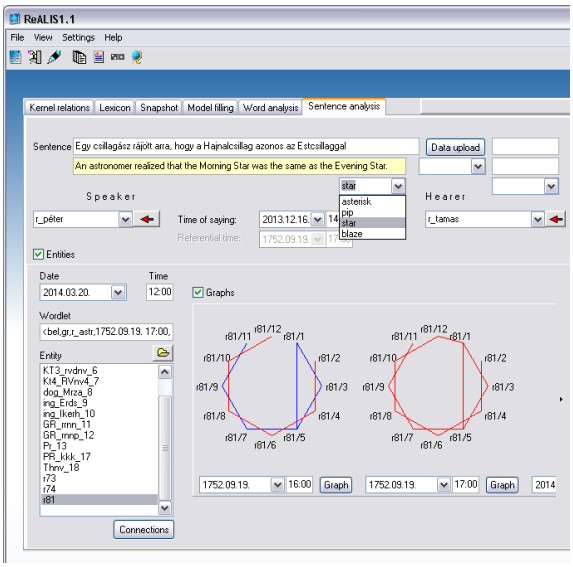


Figure 14. Interpreting the sentence shown in Fig. 3.

The software application is permanently developed and expanded, exploiting new scientific results; it has repercussions on the theory, due to the fact that the theory can be tested by means of the program. We are working on developing tests to evaluate its efficiency.

B. RUDI

As our software application inherently belongs to a radically new and holistic "pragmalinguistics" theory (Section II), it is uneasy to compare to software applications based on some different theoretical foundation. An exception is the SDRT-based experimental software dialogue system, RUDI [26], primarily due to its distinguished attention to the relationship between pragmatic phenomena and the external-world model.

RUDI ("Resolving Underspecification with Discourse Information") computes automatically some aspects of the content of scheduling dialogues, particularly the intended denotation of the temporal expressions, the speech acts performed and the underlying goals. RUDI has a number of nice features: it is a principled approximation of a logically precise and linguistically motivated framework for representing semantics and implicatures; it has a particularly simple architecture; and it records how reasoning with a

combination of goals, semantics and speech acts serves to resolve underspecification that is generated by the grammar.

RUDI analyzes such definite descriptions as requiring a bridging relation to an antecedent in the context. Fig. 15 provides an example: it should be calculated what the temporal expression '4pm' refers to in (the model of) the external world.

A: "Can we meet on Friday?"
B: "How about 4pm?"

Figure 15. Resolving the referential underspecification in the dialogue, which requires revealing the speech act type.

Neither the bridging relation nor the antecedent are determined by the compositional semantics of the utterance, however. Thus, RUDI takes the semantic representation of such expressions to contain an underspecified relation between an underspecified antecedent and the referent for the expression. A task that is co-dependent on resolving this underspecification is computing how the utterance contributes to a *coherent* dialogue. Following SDRT [22], it is assumed that a dialogue is coherent just in case every proposition (and question and request) is *rhetorically connected* to another proposition (or question or request) in the dialogue, and all anaphoric expressions can be resolved. The rhetorical relations are viewed as *speech act types* in the RUDI project—that is the point where ℜeALIS2.1 can be regarded as an extension of RUDI, given that in the ℜeALIS theory further relations among pieces of information stored in (different worldlets of) minds, addressers, addressees, contexts and the external world are (intended to be) taken into account in a completely uniform system (see Section IV-C).

It is also worth noting that the creators of RUDI [26] represent the same holistic stance typical of ℜeALIS implementations in regarding information as flowing either from resolving the semantic underspecification to computing the rhetorical relation, or *vice versa.* They, thus, consider rhetorical relations (that is, practically speech acts) to be an essential source of information for resolving semantic underspecification that is generated by the grammar.

ℜeALIS essentially follows SDRT, which represents discourse content as a "segmented discourse representation structure", which is a recursive structure of labelled DRSs [27], with rhetorical relations between the labels. In contrast to traditional dynamic semantics (see also [27], for instance), SDRT attempts to represent the *pragmatically preferred* interpretation of a discourse—just like ℜeALIS.

The rule schema used in RUDI contrasts with the plan-recognition approach to computing speech acts [89], which uses *only* the goals of the antecedent utterance, rather than its compositional and lexical semantics directly, to constrain the recognition of the current speech act. The dialogue presented in Fig. 16 illustrates the point: it depends on the particular external denotata of the temporal expressions whether interlocutor B has rejected A's proposal or has declared that (s)he is prepared for elaborating it as a common aim.

A: "Can we meet next week??"
B: "I'm busy from the 16th to the 25th"

Figure 16. Computing the speech act (Rejection or Elaboration) requires considering the temporal reference in the external world.

There are a number of advantages, thus, to allow direct access to the content of inferences. The successful performance of the current speech act is often dependent on the *logical structure* of the antecedent utterances, and goals do not reflect this logical structure; rather compositional semantics does (following DRT). An utterance in the context is chosen to which the current utterance can be attached via a rhetorical relation, and this in turn determines which antecedents are available.

C. ℜeALIS2.1 as an Extension of ℜeALIS1.1

It is very important to us that our software applications, which are permanently being developed, have repercussions on the theory, due to the fact that the theory can be tested and sophisticated by means of the program. ℜeALIS2.1, thus, has been being developed (as an extension of ℜeALIS1.1) exactly due to the enormous pragmatic extension of the ℜeALIS theory itself, demonstrated in Section IV.

Nevertheless, this part of the difference between ℜeALIS2.1 and ℜeALIS1.1 is predominantly quantitative, and not qualitative. It had also already belonged to the decisive properties of ℜeALIS1.1 that, based on the truth-evaluating pattern-matching mechanisms between linguistic representations and world models, the same kind of pattern matching is executed everywhere in the uniform system consisting of a model of the external world and a partially ordered conglomerate of its (meticulously labeled) finite human-created images we have dubbed *worldlets*. ℜeALIS2.1 is more developed than ℜeALIS1.1 in the sense that much more relations are evaluated in this intricate database, whose crucial specialty is that one and the same piece of information appears simultaneously in innumerable places in the system (just like images on different sides of a prism).

Let us overview the main problems we should cope with.

Certain difficulties have to do with the fact that we are working on a completely general toolbox that utilizes the afore-mentioned multiplied world model, that is, one that is underspecified in several respects but can be rapidly specified when it is designated for particular purposes. This also holds for the pragmalinguistics input; some difficult grammatical phenomena that must be captured in a demanding way are collected in Section IV, VI and VII-E. Due to the uniform and holistic approach of ℜeALIS, we cannot afford to use parsers or other devices developed in other projects. Elaborating sufficiently sophisticated testbeds, however, require very much cost, time, energy and creativity.

Recursivity is another stubborn problem. Unlimited chains of linguistic expressions can be produced, whose elaborated pragmatico-semantic analysis leads to proliferation problems.

It is also difficult to register the copies of multiplied entities in almost identical alternative models. We need to apply safe and effective but very rapid methods in copying

huge databases in a way that makes it possible for us to carry out the relevant differences between them.

Nevertheless, the most difficult task is the safe and systematic treatment of temporal entities, which come from the model of the external world as well as from the alternative models, and also come from the event structure of lexical items [65] and from the discourse structure of sentences to be parsed. We have been led to the conclusion that the utter key to different kinds of systematization problems is utilizing points of time as "identifying stamps".

Our ultimate task in this area, thus, is no less than modeling the episodic memory of the human mind [38]—together with the semantic memory.

D. ℜeALIS2.1 as a Model of Long-Term Memory

Leiss [50] distinguishes the aforementioned two parts of long-term memory on the basis of Tulving's research [90] as follows: "the semantic memory stores knowledge, whereas the episodic memory stores experiences".

It is relevant that, in contrast to semantic knowledge, episodic knowledge has space-time-index quality, because experience characteristically takes place in space and time, and consequently the respective space-time coordinates are mapped. As a rule, it is assumed that concepts emerge, in that experiential data are generalized so that they no longer contain space-time coordinates. The construction of episodic memory typically correlates with the acquisition of finite sentences, which, in turn, correlates with the use of inflected verbs. The function of finite sentences is to establish a reference by anchoring concepts to a space-time context. Without this technical device, autobiographical memories would not be possible. Space-time coordinates are constituted by the ATMM-complex, mentioned in Section II: by the aspect-coded space coordinates, by the time-coded tense coordinates, by mood coordinates that signal *irrealis* (i.e., statement not anchored in reality) versus *realis* in the sense of Carnap, and by the coordinates of the source of evidence the speaker relies on (see Fig. 7 in Section IV-D). The download of episodic experience by virtue of the grammatical categories aspect, tense, mood, and modality enables us to orient ourselves in the real world. These categories generate a system of coordinates that anchors our activities in the world, and which, in turn, provides indices for our memories, thereby makes them memorizable.

The very difference between semantic memory and episodic memory consists of the fact that experiences are based on the first person, whereas knowledge is based on the intersubjectification of first-person experiences. Inter-subjectification implies the neutralization of space-time coordinates, thus generating knowledge. Subjective certainty, and the download of this type of certainty, is achieved by virtue of the grammatical ATMM-categories. Here the functions of language are essential for gaining reference to the world. Objective certainty will be achieved by the never-ending construction of an intersubjectively negotiated lexicon.

We claim that, due to its lifelong character, the part of the worldlet structure of ℜeALIS where the internal entities (i.e., referents) are anchored to external entities in the world model (i.e., to real objects and persons) can readily be regarded as an implementation of episodic memory. Semantic memory consists of worldlets that contain referents that are not "out-anchored".

E. Missing Links

Due to the aforementioned ℜeALIS-model of long-term memory, the mechanisms captured in Pustejovsky's Generative Lexicon [91] can be implemented. That is, it is possible to derive "a potentially infinite number of senses for words from finite [lexical] resources," and to explain "the interpretation of words in context." This can be regarded as a qualitative innovation in ℜeALIS2.1, compared to ℜeALIS1.1.

The word *London* in (18a), for instance, is used in the given context as an attributive of the noun *train*. The problem with it is that while *a London flat* is a flat that 'can be found in London,' the London train in question is claimed to be in Bristol at the time of reference. In another context, *the London train* may refer to a train that can be found in Manchaster, in a train museum, and the attribute *London* refers to the city in which it was produced, or in which the museum can be found from which the given train has been borrowed. How can then the contextually adequate meaning be calculated?

a. "The *London* train arrived in Bristol."
b. σ relation: ⟨e1,r_{arrive},t1,r11,r12⟩; ⟨e2,r_{train},t2,r21⟩; α: ⟨r21,r11⟩
c. ⟨e3,$r_{in\text{-}London}$,t3,r31⟩; α: ⟨r31,r21⟩
d. σ relation: ⟨e4,r_{go},t4,r41,r42,r43⟩; ⟨e5,r_{train},t5,r51⟩; α: ⟨r51,r42⟩
e. ⟨e',r'_{train},t',r'1,r'2,r'3⟩
e'. ⟨e3,$r_{London.Adj}$,t3,r31⟩; ⟨e6,r'_{train},t6,r61,r62,r63⟩; α: ⟨r31,r62⟩

Figure 17. Adjectives with an unbounded number of meanings.

As was defined in Section III, the σ eventuality function is responsible for "formulating" the elementary statements the given sentence provides, from word to word. (17b) presents that it is claimed that something arrived somewhere, which is a train. What is expressed in (17c), however, is incorrect, assumed that the attributive means 'can be found in London' (as a reasonable primary meaning).

It is at this point that it is worth having recourse to the episodic memory in order to use it as a huge database. Suppose it contains episodic information expressing the fact that once 'a train went from a certain place to a certain place' (17d). If this information is deprived of the external anchors, such a temporary predicate can be constructed for the semantic memory by unifying its parts that has three arguments: 'r'1 is a train from r'2 to r'3' (17e). A copy of this temporary predicate can then be attempted to be applied in the episodic memory again, to whose *from*-argument the-entity-that-can-be-found-in-London (referent r31 in (17b)) can successfully be anchored, as is formulated in (17e'). Thus, the solution is that it is the station from which the given train departed that can be found in London.

Note that it is not excluded that other "solutions" may also come out as results; but it is sure that all results will come out that a human being is capable of finding on the basis of her or his past experiences. The emerging

"competing" results then can be compared with each other on the basis of multiplicity of computing and fitting into the broader context.

A Hungarian ontology has also been built in ℜeALIS2.1 because the above-sketched search for the context-dependent adequate interpretation of the expression *London train* can be made more efficient by attempting to replace *train* with such sister categories as *bus* and *airplane*, for instance, and *London* with *Glasgow* or *Manchester*, since the expression *Glasgow bus* can also help finding the missing link "scheduled service". We are investigating what kinds of substitution can increase efficacy, and what kinds or substitution prove to be definitely harmful.

Fig. 18 presents a verb with an underspecified meaning. In (18a), it seems to take two noun phrases as arguments; and suppose that in the case of an earlier occurrence, the associated specified meaning was 'finished reading (a book).' However, this reading is incompatible with (18a).

a. "Ed *finished* the sandwich."
b. σ relation: ⟨e2,$r_{sandwich}$,t2,r21⟩
c. ⟨e1,$r_{finish\text{-}reading}$,t1,r11,r12⟩; α: ⟨r21,r12⟩
d. σ relation: ⟨e',r'$_{finish}$,t',r'1,e'1⟩
d'. σ relation: ⟨e3,r_{eat},t3,r31,r32⟩; ⟨e4,$r_{sandwich}$,t4,r41⟩; α: ⟨r41,r32⟩
e. σ: ⟨e5,r'$_{finish}$,t5,r51,e51⟩; ⟨e6,r_{eat},t6,r61,r62⟩
e'. α: ⟨e6,e51⟩; ⟨r62,r21⟩

Figure 18. Verbs with an unbounded number of meanings.

It is reasonable to assume that the episodic memory contains, on the one hand, an occurrence of *finish* with an argument position for expressing actions (18d), and, on the other hand, information about a sandwich that has been eaten (18d'). Hence, copies of these pieces of information can be created for the semantic memory, on the basis of which, then, the story can be put together in the episodic memory, again, according to which the "sandwich finished" has been *eaten* (18e-e').

Nevertheless, other solutions may also come out, which may prove to be better in certain contexts. Ed, for instance, might have managed to *butter* the given sandwich. It is also worth mentioning that the aforementioned involvement of an ontology may also have a positive influence in finding the "missing link(s)" in the case of verbs with potentially infinite meanings. The expression sandwich, for instance, is worth attempting to be replaced with *soup* or *cake*, whose eating can also be finished.

The verb *resemble* in (19a) may also be problematic if, say, in the course of its earlier occurrence the associated specific meaning was 'resemble in being remarkably tall.' This meaning is excluded if, say, Ed is tiny.

a. "Ed *resembles* Ted."
b. σ: ⟨e1,$r_{resemble\text{-}in\text{-}being\text{-}tall}$,t1,r11,r12⟩; ⟨e2,$r_{Ed}$,t2,r21⟩; ⟨e3,$r_{Ted}$,t3,r31⟩
c. α: ⟨r21,r11⟩; ⟨r31,r12⟩
d. σ relation: ⟨e',r'$_{resemble}$,t',r'1,r'2,e'1⟩
e. σ relation: ⟨e4,r'$_{resemble}$,t4,r41,r42,e43⟩; ⟨e5,p5,t5,r51,...⟩; ⟨e6,p6,t6,r61,...⟩
e'. α: ⟨e5,e43⟩; ⟨e6,e43⟩; ⟨r51,r_{Ed}⟩; ⟨r61,r_{Ted}⟩

Figure 19. Meta-level expressions?

Such pieces of information need to be found in the episodic memory as those presented in (19d-e); first of all, an occurrence of *resemble* with an explicit *in*-argument for properties. Then predicates must be found there which have held for both Ed and Ted. We hypothesize that what should be found is not a great set of "shared" predicates, but rather a single one that is salient in some way in the context. Note that searching for predicates is not a second-order procedure in ℜeALIS because, due to reification [8], predicates are assigned to Landmanian pegs [62] in the worldlets in the same way as arguments are, so they take part in the σ relations as equal internal entities (cf. [92]).

The temporal adjective presented in (20a) patterns with the last three special words in being used not immediately as a simple predicative element. Thus, it cannot be claimed what is given in (20c), namely, that "he is former," while it can be claimed that "he is a spy," or "he is old." That is why the temporal adjective in question is called an irregular adjective by Kiefer [92].

a. "I met a *former* spy."
b. σ relation: ⟨e1,r_{meet},t1,r11,r12⟩; ⟨e2,r_{spy},t2,r21⟩; α: ⟨r21,r12⟩
c. ⟨e3,r_{former},t3,r31⟩; α: ⟨r31,r21⟩
c'. t2<t1

Figure 20. Irregular adjectives I.: temporal adjectives.

The solution of the "equation system" is quite simple in ℜeALIS, given that ordinary verbs, nouns and adjectives provide σ-formulas containing temporal referents as well. In (20b), t1 and t2 are the temporal referents. If (20a) did not contain *former*, both t1 and t2 would be identical to the reference time. The contribution of *former*, thus, is the ordering between t1 and t2 presented in (20c'). That is, the person in question is claimed to serve as a spy earlier than the time of the meeting.

We conclude this section with another adjective called irregular by Kiefer [93] essentially for the same reason: it cannot be claimed that "someone is *alleged*." The contribution of this adjective to the content presented in (21b), thus, is not (21c).

a. "I met an *alleged* spy."
b. σ relation: ⟨e1,r_{met},t1,r11,r12⟩; ⟨e2,r_{spy},t2,r21⟩; α: ⟨r21,r12⟩
c. ⟨e3,$r_{alleged}$,t3,r31⟩; α: ⟨r31,r21⟩
c'. level λ of e2 (rel. to e1): ⟨B,M,r*,τ,+⟩

Figure 21. Irregular adjectives II.: modal adjectives

The solution of this puzzle has to do with the crucial weapon of ℜeALIS: the contribution of *alleged* is that infon e2 (according to which someone is a spy) must be set in a worldlet different from the worldlet in which e1 is to be set (according to which the speaker met someone). While it is claimed by the speaker, thus, that (s)he met someone, the claim that he is a spy is attributed to another person by the speaker (21c').

VIII. SUMMARY

We have intended to convince the reader that it is not a huge cost for the (theoretical, and then computational) treatment of such "internal questions of language" as sentence types (Sections III-IV), honorification, epistemic and deontic modality, evidential and mirative markers, expression of politeness, special intonations (Section IV), tense, aspect, subjectivity, deixis (Section VI), irregular adjectives, and the problem of deriving a potentially infinite number of senses for words from finite lexical resources (Section VII) to attempt to formally describe information states of human minds in communication—that is, the human mind itself (Section I).

Our ambitious stance can be legitimized by the Un-Cartesian philosophical hypothesis on language, defended by Leiss [38] as follows: "...language is a type of translation of the world into mental representations. Language is a technical device for diagrammaticizing the world. It is not a device that directly reflects the world, but rather a motivated reduction of the complexity of reality through transduction into more or less specified diagrams of the world. Language enables us to
do with the assistance of the technique of grammar (referential opposition of concepts), which enables us to orient ourselves in the real world in space and time. Beyond that, language provides the option, again on the basis of the construction of concepts, to generalize experiential certainties, thereby making them usable in contexts hitherto unexperienced."

This paper demonstrates what kind of ontological innovation (Section II) and mathematical techniques (Section III) are required to metamorphose the DRT-hierarchy of Montagovian logical subformulas into intensional profiles of (expositive) speech acts, on the one hand, and descriptions of its addressers' and addressees' current information states, on the other hand, which can then be readily compared with each other—in the form of some kind of "generalized truth-evaluation" (including the checking of all kinds of semantic and pragmatic felicity conditions), as is claimed in Section IV.

Then our software application ℜeALIS1.1 is demonstrated through discussing its different kinds of potential users and its main use cases for the users we call internal users and for those we call external users (Section V). Section VII presents the additional services of ℜeALIS2.1 as compared to ℜeALIS1.1 and an SDRT-based experimental software application called RUDI. We point out that ℜeALIS2.1 can be regarded as a model of the two parts of long-term memory—episodic and semantic memory—and this enables us to calculate new senses for words "in contexts hitherto unexperienced," as was formulated above (see also the illustration in Fig. 22).

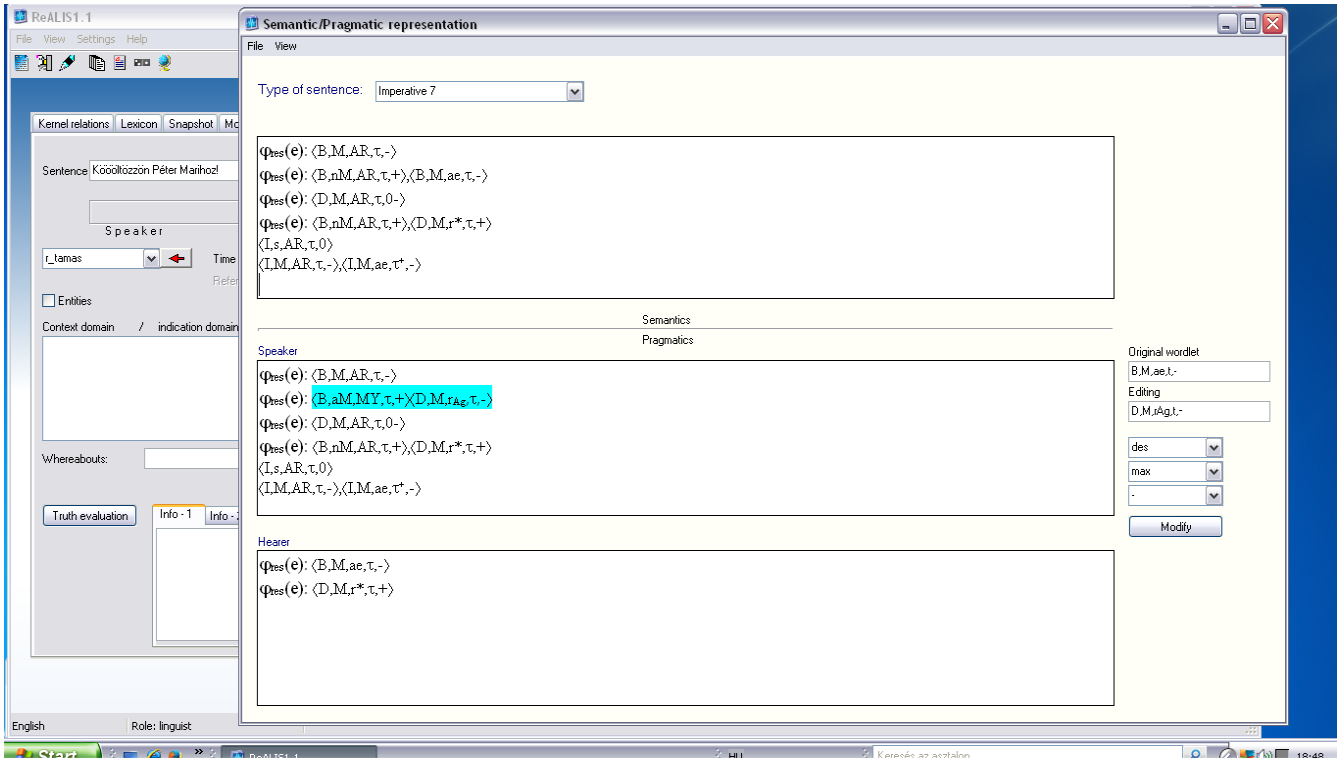


Figure 22. Comparison between the intensional profile of a proto-imperative speech act and the addresser's and the addressee's intensional profile.

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