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The Matrix of Beliefs, Desires and Intentions – Sentence by Sentence

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ABSTRACT

This paper is grounded in the dynamic semantic [7] model ℜeALIS [1] about human interpreting 'minds' as they are in communication with each other. Following in the footsteps of studies [3-4], here we offer a text analysis method which proceeds from sentence to sentence and thus gradually opens up the intensional status of the information as it is obtained by the hearer. 'Matrix' here refers to a combination of a pragmatic text analysis (e.g. through the formalization of Grice's approach [5]) and the intensional messages of linguistic clues [3–4]. Within the matrix, the elements of intensionality cease to exist as sporadic 'specialties'. Rather, an inherent part of the semantic content of each given sentence is the information concerning what beliefs (and each with what level of certainty), desires and/or intentions the speaker has, as well as what he/she thinks in the same respect about his/her conversational partner, and also what the partner thinks of him/her correspondingly, and so on. In an implementation of ℜeALIS, numerical matrices were developed [2], which produce the truth-conditional interpretation of the sentences that are attributed to particular agents as speakers at certain moments. This method makes it possible to interpret various opinions connected to the sentences – opinions like "This has been a (white) lie / a bluff," or "The speaker has killed the joke."

KEYWORDS: *representational dynamic discourse semantics, intensionality, information state*

1 Introduction

This paper is grounded in the dynamic semantic [7] model ℜeALIS [1] about human interpreting 'minds' as they are in communication with each other. Following in the footsteps of studies [3–4], here we offer a text analysis method which proceeds from sentence to sentence and thus gradually opens up the intensional status of the information as it is obtained by the hearer. 'Matrix' here refers to a combination of a pragmatic text analysis (e.g. through the formalization of Grice's approach [5]) and the intensional messages of linguistic clues [3–4].

Within the matrix, the elements of intensionality cease to exist as sporadic 'specialties'. Rather, an inherent part of the semantic content of each given sentence is the information concerning what beliefs (and each with what level of certainty), desires and/or intentions the speaker has, as well as what he/she thinks in the same respect about his/her conversational partner, and also what the partner thinks of him/her correspondingly, and so on.

2 Formalization

Let us take a simple example to evoke the theory put forth in [1] and the technical apparatus presented in our 2012 CICLing publication [4]: *Mary is at home*. Here the 'primary' segment of the information state (Γ_s^0) in Grice's ideal speaker holds that eventuality *e*, registering Mary's being at home, is thought honestly true by him/her (speaker *s*). With the formal apparatus of ℜeALIS, this piece of knowledge can be captured in the representation of the speaker's mind as a 'worldlet', which can be characterized by the following five-item label: ⟨BEL, max, s, τ, +⟩. The first parameter (in this case 'BEL') shows modality. 'MAX' indicates a higher level of belief or belief with the power of "knowledge". Symbol *s* refers to the speaker; τrefers to time; while + refers to a possible polarity (π_1). (In a later phase of the research, we will introduce further parameters for emotion and style.) Compared to the above, the relevant segment of the information state (Γ_i^0) in the interpreter who enters the conversation in an "ideal" manner can be described as follows:

(1) $\Gamma_i^0=\{\langle BEL,max,i,\tau,0\rangle, \langle DES,great,i,\tau,+\rangle\langle BEL,max,i,\tau',\theta\rangle\}$

Conversational partner *i* is therefore not aware of the eventuality being true or not (π=0) but has a strong desire (DES) for it to turn out.

This is what symbol '0' (drawn zero) refers to. It should be noted that the gratification of the above desire in a latter phase of the communication is represented in the hearer's mind by the appearance of a + or a – in the place of the drawn zero. It would be a mistake, however, to infer from this a "dangerously four-rated" background-logical calculus: we do not suggest that an operational chart can be directly assigned to these four rates. Pragmatic rules can only be set up for complex lists of label-series.

We note here for those well-acquainted with logics that the rules to be provided here concern, in general terms, those sub-structures present in the cognitive network of information states which can be formalized. This way, we aim to sidestep the logical approaches which to a linguist might seem too "sterile", idealized or simplified.

The next level of representation shows that the information states of the conversational parties contain a great number of assumptions (of different states) about their partner's internal worlds. The speaker intends to alter the hearer's information state by letting him/her know that *e* is true. In addition, he/she makes it probable ('great') that his/her hearer is an "ideal" one in the earlier sense of the word (namely that he/she can be described with the start-out information state (Γ_i^0):

$$(2) \qquad \Gamma_s^1=\{\langle \mathrm{INT,max,s,\tau,(\pi_2=)+}\rangle\langle \mathrm{BEL,max,i,\tau',+}\rangle\} \cup \{\langle \mathrm{BEL,great,s,\tau,+}\rangle\} \wedge \Gamma_i^0$$

The second segment of the hearer's information state can be represented in a similar way:

$$(3) \qquad \Gamma_i^1=\{\langle \mathrm{BEL,great,i,\tau,+}\rangle\} \wedge (\Gamma_s^1 \cup \Gamma_s^0)$$

Formulas are applied as formal representations of the n^{th} segment of both the speaker's and the hearer's information states, in a most general way:

$$(4) \qquad \Gamma_s^n=\{\langle \mathrm{BEL},1/(n+1),\mathrm{s,\tau,+}\rangle\} \wedge \Gamma_i^{n-1},$$
$$\Gamma_i^n=\{\langle \mathrm{BEL},1/(n+1),\mathrm{i,\tau,+}\rangle\} \wedge \Gamma_s^{n-1}.$$

The deeper the recursion is, the smaller the fraction. This suggests a decrease in the intensity of knowledge – namely that we have increasingly vague ideas about information contained by segments of information states which are farther and farther away from the initial segments. In an actual communication situation the participants can barely rely on $n > 2$ cases. In formal (generative) linguistics, nevertheless, it is not

proper to exclude competence to a deeper recursion already at the start. The potentially unlimited union of the unrestrained (as for *n*) appropriate segments evokes the absolute sum of the speaker and the hearer's relevant information in the actual communication situation: $\cup\Gamma_s^n$ and $\cup\Gamma_i^n$.

So far we have described an ideal communication situation – ideal in the Gricean or in a post-Gricean sense. The chart below demonstrates that changes to the parameters of certain 'worldlet' labels can also capture non-ideal communication situations such as in the cases of misleading or lying.

Although the concept of an 'ideal communication situation' is widely used in pragmatics, it is very difficult to pinpoint. For a communication situation to be ideal it takes ideal partners (a hearer and a speaker) and ideal circumstances.

In the present paper, the meaning of 'ideal' shall be extended beyond the Gricean sense. 'Ideal' here means some kind of smoothness when nothing disturbs the smooth flow of conversation. Course books and foreign language books, for example, typically feature ideal speech situations to illustrate humorless but easy-to-process discourse. The reason why it is crucial to mark off the case of an ideal communication situation is because all other (deviant) cases can be correlated to it; this, then, makes it possible to allocate all the different situations in one system. Grice's theory and maxims come handy when one wants to demonstrate what the ideal situation is like since they provide a good enough definition for the "obligations" of the speaker who does not wish to upset the flow of this more or less humorless conversation in any way.

Earlier it has been said that the conversational parties aim to keep to a common goal. Now this may be misleading if taken in the strict sense: it may well be that it takes a certain degree of non-ideality for human conversations to be diverse in nature. It can be well presumed that most of the conversations one encounters day by day do not conform to the genuinely, *per definition* ideal standard. Also, most of the ideal communication situations are to be found in formal contexts (which are not devoid of misunderstandings, either). When one is talking to his/her immediate friends, he/she economizes on very little information in order to save time for both parties – almost to an extent of breaching Grice's maxim of quantity. Very probably, many of us have had the feeling of hardly being capable to provide answers to our partners that would be long and detailed enough. Oftentimes, we may have the feeling of only being capable of hurling fragments of information

on the other one (while breaking the maxim of manner) in the hope that every situation becomes clear at some point. Again, our answers to certain questions may not satisfy the needs of the questioner at all; we use them in order to dissuade the questioner from further questioning (e.g. “What did you have for lunch at school?” “A first and a second course.”).

Yet, every discourse features the common goal above somehow – except that in most of them this goal is not reached in a straightforward way. It has been mentioned earlier that the concept of an ideal speaker and hearer is necessary to allocate ideal and various non-ideal situations in one system. Although it is a daring idea to divide all communication situations into ideal and non-ideal, this is a necessary step to take here. Cases on the vague borderline between the two types of situations will not be addressed here; ‘ideal’ in this paper shall refer to a speaker and a hearer as they were specified above, while all other behavior of the speaker and the hearer shall be perceived as ‘non-ideal’. The present paper focuses on cases where the speaker improperly or poorly identifies the desires of his/her conversational partner and where he/she misleads their partner on purpose. In addition, the paper will also attempt to account for the mistakes of the hearer.

3 Polarity

In what follows, Π (marker of polarity) is replaced by +, –, 0 or ϴ. These changes enable the system of formalization to handle different non-ideal communication situations.

(5) $<BEL,max,s,\tau,\Pi^1>$

The speaker’s knowledge of e

(6) $<BEL,great,s,\tau,\Pi^2><BEL,i,\tau,\Pi^3>$

The speaker’s knowledge about the hearer’s knowledge of e

(7) $<BEL,great,s,\tau,\Pi^4><DES,i,\tau,\Pi^5><BEL,i,\tau',\Pi^6>$

The speaker’s knowledge about the hearer’s desire of e

(8) $<INT,max,s,\tau,\Pi^7><BEL,i,\tau',\Pi^8>$

The speaker’s intension of the hearer’s knowledge of e

The chart below (9) shows the differences between the various formalized situations as regards changes in polarity. The chart makes it easy to assess the differences between the polarity adjustments of various situations. It can be seen, for instance, that all cases of misleading (from concealing information to lying) share the fact that there is a difference in the polarities of their parameters Π^1 and Π^8. This indicates a difference between what the speaker knows and what the speaker desires the hearer to (not) know. In other words, the speaker is expected to pass on information to the hearer about which he/she is convinced as being not true or about which he/she is not convinced as true. It may also happen that the speaker provides the hearer information that the latter one does not desire to have.

(9) Situations and ℜeALIS Polarity Values:

Π^1	Π^2	Π^3	Π^4	Π^5	Π^6	Π^7	Π^8	SITUATIONS
+	+	0	+	+	~~0~~	+	+	Ideal
+	+	+	+	0	~~0~~	+	+	Clarification
+	+	–	+	0	~~0~~	+	+	Correction
+	+	0	+	+	~~0~~	+	0	Concealing
0	+	0	0	+	~~0~~	+	+	Bluff
+	+	0	+	0	~~0~~	+	–	Fib
+	+	0	+	+	–	+	–	White lie
+	+	0	+	+	~~0~~	+	–	Lie

In the first two situations neither misleading nor lying takes place on the part of the speaker. By changing the variability of the polarities, however, very interesting situations can be illustrated – such as, for example, when the speaker corrects the hearer or clarifies the information that both of them have.

4 Clarifications

Making a clarification can be easily captured in the words ‘so’ and ‘OK, so’. The hearer and the speaker have the same information but the speaker finds it important to clarify this fact (to avoid later misunderstandings).

(10) Γ_s^0 ={<BEL,max,s,τ,+>}
Γ_s^1 ={<BEL,great,s,τ,+><BEL,i,τ,+><BEL,great,s,τ,+>
<DES,i,τ,0><BEL,i,τ',~~θ~~><INT,max,s,τ,+><BEL,i,τ',+>}

The speaker knows that Mary is at home. The speaker strongly believes that the hearer does not know whether Mary is at home or not. The speaker strongly believes that the hearer would like to know, in a later moment, that Mary is at home or not. The speaker intends the hearer to believe that Mary is not at home.

5 Corrections

Making a correction is similar to making a clarification. The speaker knows that the hearer is wrong so the former corrects the latter. This is what the words 'yes, indeed' indicate in the dialogue.

(11) Γ_s^0={<BEL,max,s,τ,+>}
Γ_s^1={<BEL,great,s,τ,+><BEL,i,τ,->,<BEL,great,s,τ,+>
<DES,i,τ,0><BEL,i,τ',~~θ~~>,<INT,MAX,S,T,+><BEL,I,T',+>}

The speaker knows that Mary is at home. The speaker strongly believes that the hearer does not know whether Mary is at home or not. The speaker strongly believes that the hearer would like to know, in a later moment, that Mary is at home or not. The speaker intends the hearer to believe that Mary is not at home.

6 The Speaker Kills the Joke

The speaker kills a joke when he/she shares a piece of information too early with the hearer, which he/she only wanted to find out later on. The hearer wants to get a certain piece of information about e only in a later moment of time; the speaker, however, driven by an ill purpose, disrespects this want on the listener's part. A classic example of this is "spoilerism", when someone deliberately hints information on the plot of a book or film that the other one has not yet read or seen. Although no lying or misleading takes place here, the situation is far from ideal.

(12) Γ_s^0={<BEL,max,s,τ,+>}
Γ_s^1={<BEL,great,s,τ,+><BEL,i,τ,->,<BEL,great,s,τ,+>
<DES,i,τ,-><BEL,i,τ',~~θ~~>, <BEL,great,s,τ,+><DES,i,τ,+>
<BEL,i,τ'',~~θ~~>, <INT,MAX,S,T,+><BEL,I,T',+>}

The speaker knows that Mary is at home. The speaker strongly believes that the hearer does not know whether Mary is at home or not. The speaker strongly believes that the hearer would like to know, in a later moment, that Mary is at home or not. The speaker intends the hearer to believe that Mary is not at home.

7 Concealing

When the speaker wants to conceal something from the hearer, no lying takes place, but the speaker misleads the hearer.

(13) Γ_s^0={<BEL,max,s,τ,+>}
Γ_s^1={<BEL,great,s,τ,+><BEL,i,τ,0>,<BEL,great,s,τ,+>
<DES,i,τ,+><BEL,i,τ',~~0~~>, <INT,max,s,τ,+><BEL,i,τ',0>}

The speaker knows that Mary is at home. The speaker strongly believes that the hearer does not know whether Mary is at home or not. The speaker strongly believes that the hearer would like to know, in a later moment, that Mary is at home or not. The speaker intends the hearer to believe that Mary is not at home.

Another subtype of concealing is when the speaker – breaking the maxim of quantity (and relevance) – "talks the hearer's arm off". Here, since the information being passed is true, no lying takes place, but the information is such that the hearer does not want to know or which does not add to the conversation. The hearer expects certain information but instead of getting that, he/she gets another piece of information, which is true but that does not matter for the hearer. A wide range of linguistic (slang) expressions are available to describe this activity (talk someone's head/arm/pants off, talk the bark off the tree, talk a blue streak, beat about the bush…). One may sense slight semantic differences between these expressions, but those might well only result from individual language use.

8 Bluffs

When a speaker bluffs, he/she gives the hearer information whose truth he/she is not confident about. He does so to fulfill his/her (ill) purpose. This interpretation of bluffing is different from the term as it is used in

poker (where it is a simple lie without words). Concentrating instead on the colloquial use of the word 'bluff', it can be explained as follows.

(14) Γ_s^0={<BEL,max,s,τ,0>}
Γ_s^1={<BEL,great,s,τ,+><BEL,i,τ,0>,<BEL,great,s,τ,+>
<DES,i,τ,+><BEL,i,τ',θ>, <INT,max,s,τ,+><BEL,i,τ',+>}

The speaker knows that Mary is at home. The speaker strongly believes that the hearer does not know whether Mary is at home or not. The speaker strongly believes that the hearer would like to know, in a later moment, that Mary is at home or not. The speaker intends the hearer to believe that Mary is not at home.

We should note here though that 'bluff' is also used in the following sense: In a less formal situation of a job-interview, the applicant may bluff about his/her English language proficiency or about his/her earlier experiences in order to get the job, knowing at the same that there will be no chance for this little 'fib' to turn out later on. Children's bluffs may be considered a similar case. While parents may often catch their kids bluffing, they do not expose each and every one of their bluffs since those are perceived as a natural accompaniment (up to a certain aspect) to being a child.

9 Fibs

Telling stories or fibbing is a case of lying: the speaker gives the hearer some information while he/she is convinced that it is not true. The difference between a fib and a lie is hard to tell. It is not only the level of seriousness that makes a difference between them. In risk-free fibbing, the speaker assumes that the hearer does not need the information at all (this lends fibbing a risk-free nature). For example, a husband can tell his wife without any risks that he has paid the bills (while he has not) because he can do it the next day and with this, he can straighten out the pity lie. The fibber is not driven by anything bad; he acts to protect his face.

(15) Γ_s^0={<BEL,max,s,τ,+>}
Γ_s^1={<BEL,great,s,τ,+><BEL,i,τ,0>,
<BEL,great,s,τ,+><DES,i,τ,0><BEL,i,τ',θ>,
<INT,max,s,τ,+><BEL,i,τ',->}

The speaker knows that Mary is at home. The speaker strongly believes that the hearer does not know whether Mary is at home or not. The speaker strongly believes that the hearer would like to know, in a later moment, that Mary is at home or not. The speaker intends the hearer to believe that Mary is not at home.

10 White Lies

White lies also belong to lying. It is not their risk-free nature that distinguishes white lies from real lies but the intention behind them. The speaker so-called "maps" the hearer's desire about *e* and tries to satisfy it.

Speaking of white lies, doctor-patient dialogues readily come into mind. Suppose a patient has very little chance of recovering. Knowing this fact may even worsen his/her well-being, so neither the doctor nor the family communicates this information to him/her. It can also be regarded as a white lie when someone compliments on someone else on their hair style (even though it looks awful) to make them feel good. Looking at the motifs and goals behind white and non-white lies, it becomes clear what makes them different: white lies are generally governed by good intentions – as opposed to lies, which are cases of pure crime. Here, too, formal explanation comes from a reason beyond form, which at the same time makes the phenomenon ready to be formalized. The hearer wants to get hold of a piece of information and – although the opposite of the information-content is true – the speaker chooses to satisfy his/her partner's desire rather than comply with the maxim of quality and not lie.

(16) Γ_s^0={<BEL,max,s,τ,+>}

Γ_s^1={<BEL,great,s,τ,+><BEL,i,τ,0>,
<BEL,great,s,τ,+><DES,i,τ,+><BEL,i,τ',->,
<INT,max,s,τ,+><BEL,i,τ',->}

The speaker knows that Mary is at home. The speaker strongly believes that the hearer does not know whether Mary is at home or not. The speaker strongly believes that the hearer would like to believe, in a later moment, that Mary is not at home. The speaker intends the hearer to believe that Mary is not at home.

11 Lies

A clear-cut case of lying is when the speaker gives the hearer some information while he/she is convinced that it is not true.

(17) Γ_s^0={<BELmax,s,τ,+>}
Γ_s^1={<BEL,great,s,τ,+><BEL,i,τ,0>,
<BEL,great,s,τ,+><DES,i,τ,+><BEL,i,τ',~~0~~>,
<INT,max,s,τ,+><BEL,i,τ',->}

The speaker knows that Mary is at home. The speaker strongly believes that the hearer does not know whether Mary is at home or not. The speaker strongly believes that the hearer would like to know, in a later moment, that Mary is at home or not. The speaker intends the hearer to believe that Mary is not at home.

12 Implementation

In an implementation of ℜeALIS, numerical matrices were developed by our close colleagues [2] to produce the truth-conditional interpretation of the sentences that are attributed to particular agents as speakers at certain moments. Due to the advantageous feature of ℜeALIS to represent the interpreters' minds as maps containing the labels discussed above as guideposts [4], the method makes it possible to interpret various opinions connected to the sentences – opinions like "This has been a (white) lie / a bluff," or "The speaker has killed the joke". The program simply has to seek the guideposts for the appropriate configurations of polarity values.

In what follows, the relevant properties of the implemented interpretation system are sketched out.

Instead of input sentences, it is better to choose the model of the external world for a starting point. The model consists of relations, each of which has time intervals as one type of its arguments. The relation corresponding to the verb *snow*, for instance, is a binary one which associates time intervals with spatial entities (i.e. it is given when it snows where). The relation corresponding to the adjective *bald* associates time intervals and entities which correspond to people. *Live* (or *be somewhere*) is a tertiary relation with the following types of entities as arguments: a person, a spatial entity and a time interval. *Know* (*somebody*) is also a tertiary relation with two persons and a time interval as its argument types.

The fact that a certain *n*-tuple of entities can be found in a certain relation is defined as an *infon* ([8]:242). Truth-conditional evaluation primarily relies on infons. The sentence *It is snowing* is true, for instance, if its performance is attributed to a moment *t* of time and a person whose location is a spatial entity *s*, where there is an infon of *snowing* with a time interval *T* containing *t* and a place *S* containing *s*. Similarly, the sentence *Peter knows Mary* is true if its performance is attributed to a moment *t* of time (as well as a speaker and an addressee) so that there is an infon of *knowing* with a time interval *T* containing *t* and the entities assigned to the names in question in the appropriate order (the explanation of the complex way in which this assignment is dependent on the speaker's and the addressee's information states is beyond the scope of this paper).

In an elegant linguistic model, the truth of the sentence *Mary is at home* does not directly rely on one single infon but (at least) on two infons and a meaning postulate, saying that *x is at home if x is in a place s such that x lives in s* (the knowledge of the meaning postulate is held to belong to the selected speaker's information state).[1]

In ℜeALIS [1], each "interpreter" (human being) is an entity of the world model and has further entities ("internal" ones) at his/her disposal. Situations (1-17) illustrated some varieties (of certain parts) of an interpreter's labeled network which expresses his/her momentary information state. What is crucial is that these internal networks (are defined so that they) also belong to the system of relations of the world model.

In a realistic implementation of ℜeALIS, each interpreter's information state at point *t* of time can be regarded as a modified (partial) copy (or "photograph") of the "active" infons (whose time intervals contain

[1] All heterogeneous events (e.g. *travel home* or *lose weight*) are to be evaluated via meaning postulates based upon homogeneous events that have direct connections to infons because it is more economical to define the external world model by means of a meager ontology, in which infons correspond to homogeneous events. The definition of *travel home*, for instance, can rely on eventualities associated with "earlier" and "later" points of time: e.g. *x travels home if x is travelling at t', and x intends to be at home, and x is at home at a later moment t"*, etc. The system for the components of this meaning postulate can be broadened in a sophisticated linguistic model, but the application of certain components will depend on tense and aspect. The sentence *Mary was travelling home*, for instance, does not require satisfaction of the last component mentioned above (*x is at home at a later moment t"*) to be true; the intention also mentioned above is essentially enough ([5]:147, *Imperfective Paradox*).

t). A perfect copy would mean that an interpreter's information state is such that it contains a corresponding eventuality referent for each active infon, represented in the following trivial worldlet-label family: {⟨BEL,max,s,τ,+⟩}. This would mean a supernatural interpreter who would be aware of all current facts of the on-going external world. Users of our software can apply this "oracle"-mode but they can also choose to modify the worldlet-label families associated with eventuality referents to develop realistic interpreters. In the case of a realistic interpreter, the label family is only associated with an eventuality (except for cases with a small set of eventualities): {⟨BEL,max,s,τ,0⟩}. This means that the given interpreter knows nothing about the eventualities in question; an ordinary human being only has a *partial* snapshot of the surrounding world. In the case of a small set of eventualities, however, each eventuality in the information state of the realistic interpreter is associated with at least as complex worldlet-label families as those shown in (1-17). Instead of, or in addition to, knowing that *e* is true, the interpreter knows, for instance, that another person believes that *e* is false, and/or (s)he wants this person to believe that *e* is true, and/or (s)he wishes that a third person would intend to convince the second person that *e* is true, etc. What we argue here is that a human being has a *modified* snapshot of the surrounding world, compared to the perfect picture at a potential oracle's disposal.

This approach, thus, provides a manifold mirroring of external relations. The capriciously modified images and the genuine relations all belong to the same relational system whilst, due to what we call worldlet-labels, the internal status of each "image" is precisely defined and is detectable within a particular information state which belongs to a particular interpreter. This results in the fact that the evaluation of sentences (18a–c) – discussed above – is not significantly simpler than the evaluation of the sentences shown in (19) (whose interpretation requires an intensional apparatus in other logical systems).

(18) a. It is snowing.
b. Peter knows your brother.
c. Polly is at home.

(19) a. Peter believes that it is snowing.
b. Peter has discovered that it is snowing.
c. According to Ann, Brian believes
that Cecil wants Mary to be at home.
d. According to Brian, Mary is pretty.
e. Mary is pretty.

The evaluation of sentences in (18) required *pattern matching* which pertains to active infons of the external world, where activity can be defined on the basis of when (time), where (place) and by whom (speaker) the given sentence is performed. What (18a) illustrates excellently is that no sentence can be evaluated without attributing its performance to an interpreter with an entirely elaborated information state. (18b) shows that the addressee should also be decided on for truth-conditional evaluation. In (18c), Polly is used as a nickname for Mary; we intend to call the reader's attention to the fact that it is a prerequisite for the evaluation of sentence (18c) that (in the ideal case) both the speaker and the addressee use this nickname for a certain Mary.

The evaluation of sentences in (19) also requires pattern matching. The only difference is that the appropriate patterns should not (only) be detected in the area of infons but also in other areas of the relational model of the entire world.

In (19a), it is irrelevant if it is snowing "outside"; what matters is that a certain segment of the information state belongs to a person who is a 'unique' Peter to the speaker in the given context.

(19b) requires a more complex investigation. The external world also matters: it must be snowing outside; and Peter's two information states at two points of time should be searched. It is required that in the earlier state, but not in the later state, the eventuality of snowing is *not* associated with a label like this: $\langle$BEL,max,s,τ,+$\rangle$.

The evaluation of sentence (19c) essentially requires the discovery of a special segment of the internal network of an interpreter. We should enter the information state of a person who is known by the speaker as Ann; then we should find this Ann's beliefs concerning Brian's beliefs, especially those concerning Cecil's wishes. This is a long path but it also ends in pattern matching.[2]

(19d) is to be evaluated on the basis of the information state of the person known as Brian to the speaker and chosen by the user of our program. What we would like to illustrate here is that in the case of an intensional predicate like *pretty*, it is easier to evaluate somebody's opinion than to evaluate a seemingly objective proposition like the one in (19e). Our solution relies on the approach that no infon corresponds to *pretty*, but the interpreters' current opinions should be searched. To be pretty means to be pretty according to the majority. In a more sophisticated approach, which is easily available in our system, the in-

[2] Here again, the problem of names/nicknames arises and probably results in ambiguity. We do not enter into details here.

formation states of those assumed to be known (and respected) by the selected speaker should be looked at; some relative majority will decide on the question of prettiness.

At the end of the section, let us note that the speaker-dependent truth-conditional evaluation of sentences like those in (19) requires the same background architecture as the evaluation of certain pragmatic reactions attributed to the hearer such as in "This has been a (white) lie / a bluff" etc. Here – as in the latter example – we have a further typical case to investigate: the case of worldlet-label families that are associated with (a) given eventuality referent(s) in the speaker's information state(s) (probably in addition to infons).

13 Further Goals

Going farther in and deeper down in the levels of recursion (cf. sections 4–11), there are several further situations waiting to be formalized, beyond the scope of the present paper. One of our further goals, in fact, includes the formalization of longer dialogues with several turns.

As for real-life implementation, our system could be used, for instance, to make a judge's work easier. The information state of each party concerned in a case could be registered at any selected point of time (e.g. as regards their beliefs and intentions related to external facts and/or one another); in order to prove, for example, that a given person could not have been aware of a given fact at a given point of time

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References

1. Alberti, G.: ℜeALIS: An Interpretation System which is Reciprocal and Lifelong. Workshop 'Focus on Discourse and Context-Dependence' (16.09.2009, 13.30-14.30 UvA, Amsterdam Center for Language and

Comm.), http: // www.hum.uva.nl / aclc / events.cfm / C2B8E596-1321-B0BE-6825998CFA642DB2, http://lingua.btk.pte.hu/realispapers (2009)
2. Alberti, G., Károly, M., Kilián, I., Kleiber, J., and Vadász, N.: The moment of truth – or the anchoring function α of ℜeALIS from the scope of Hungarian [in Hungarian]. In: Vincze, V, and Tanács, A. (eds.): Ninth Hungarian Conference on Computational Linguistics. Dept of Informatics, Univ. of Szeged, Hungary, pp. 236–250 (2013)
3. Alberti, G. and J. Kleiber: Where are Possible Worlds? (Arguments for ℜeALIS). Acta Linguistica Hungarica 59 (1-2) (ed. Katalin É. Kiss). 3–26 (2012)
4. Alberti, G., and M. Károly: Multiple Level of Referents in Information State. A. Gelbukh (ed.): Computational Linguistics and Intelligent Text Processing, CICLing2012, New Delhi, India. Lecture Notes in Computer Science LNCS7181. Springer Verlag, Berlin, Heidelberg, pp. 34–362 (2012)
5. Dowty, D. R.: *Word Meaning and Montague Grammar*. Reidel, Dordrecht (1979)
6. Grice, P.: Logic and conversation. In: Cole, P. & Morgan, J. (eds.): Syntax and Semantics 3. New York, Academic Press, pp. 41–58 (1975)
7. Kamp, H., van Genabith, J., Reyle, U.: Discourse Representation Theory. In Handbook of Philosophical Logic, vol. 15, pp. 125–394. Springer-Verlag, Berlin (2011)
8. Seligman, J., Moss, L. S.: Situation Theory. In van Benthem, J., and ter Meulen, A. eds.: Handbook of Logic and Language. Elsevier, Amsterdam, MIT Press, Cambridge, Mass, pp. 239–309 (1997)

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