

D-script model for synthesis and analysis of emotional speech

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Abstract

In the present issue we discuss a theoretical model for processing of emotional speech during text analysis and synthesis. The model is developed for description of speech influence in affective mass media texts and also applies to several other types of emotional communication, including conflict, complaint and speech aggression.

The model follows H-CogAff architecture of cognitive models and distinguishes units for “rational” inference (r-scripts) and units for “emotional” processing of meaning (d-scripts). We claim that certain semantic components can stimulate emotional processing, activating d-scripts and suppressing possible rational inference (r-scripts) – the same semantic components appear in emotional text during text synthesis. Such “affective” semantic components are described as starting models of d-scripts. The model allows to describe semantic properties of “emotional” texts and (to certain extent) to model types of speech behaviour in emotional situations.

1. Introduction

The interest in functional interpretations of emotional communications is recently growing in several areas of linguistics and computer studies. As noted in [10] the interest to computer models of emotions is caused above all by (i) interest in functional description of emotion, explaining of emotions through modelling, (ii) a desire to create computer models, which could model emotions of a user and (iii) intention to create computer agents (either “toy” robots or pieces of software), which could experience, or rather simulate emotional behaviour in interaction with a user or with a simulated or real world.

In linguistics the interest to emotional texts and communication is also explained by (i) the desire to describe new material, which was previously considered as “non-linguistic” (or, at least peripheral) object of studies, and (ii) the desire to satisfy the requests from the applied areas of studies: above all, theory of advertising and practice of juridical linguistic expertise [17].

A good solution for the description of emotional text interaction would be a theoretical (or computer) model, experiencing speech influence and constructing emotional texts (corresponding to simulated “emotional

states”) in the same way as an assumed human being. In our studies of speech influence we have proposed a theoretical model, where we have distinguished procedures for “emotional” and “rational” processing of incoming texts, and defined preference rules, which suggest, which way of processing (“rational” or “emotional”) a listener would prefer for a given text in a “neutral” condition.

The theory was originally developed on the texts of election campaigns to Duma in 1999, and in particular, on the texts of a TV journalist S. Dorenko. Further, the model was verified on the texts of 2003 Duma elections.

An applied “non computer” application of this theory would be a work of an expert, engaged in text analysis and interested to find certain “affective contents”. An extension of this theory would provide a basis for artificial construction of simple “affective” texts, for the needs of advertising.

The same model of affective text processing, however, covers not only mass media influence, but also several other types of affective communication – including speech influence in everyday personal communication. As emotional processing may result in an emotional reply, the model can therefore, apply to text synthesis in an “emotional condition” (simulating emotional utterances), and further – text analysis in a “non neutral” state of the listener.

The processes are managed by the d-scripts, a set of procedures in the total structure of the model, responsible for the affective processing of speech. In the present issue we discuss the general architecture of a d-script and application of the model to simulation of emotional speech interaction.

2. General Architecture of the Model for the Processing of Affective Meanings

The general representation of the model has to change its state following an arrival of some affective text, and, possibly – give a signal to some behavioural action. As usual in “negative” mass media propaganda an addressee has to receive an affective utterance aimed against some political party, and as a result – vote for the opposition. So, a simple theory of speech influence has to provide a link between the perception of an affective text and some aggressive action (as we deem protest voting as restrained aggression). In particular, as we start from a rather simple model, it has to react emotionally on utterances like (1) *The governments is*

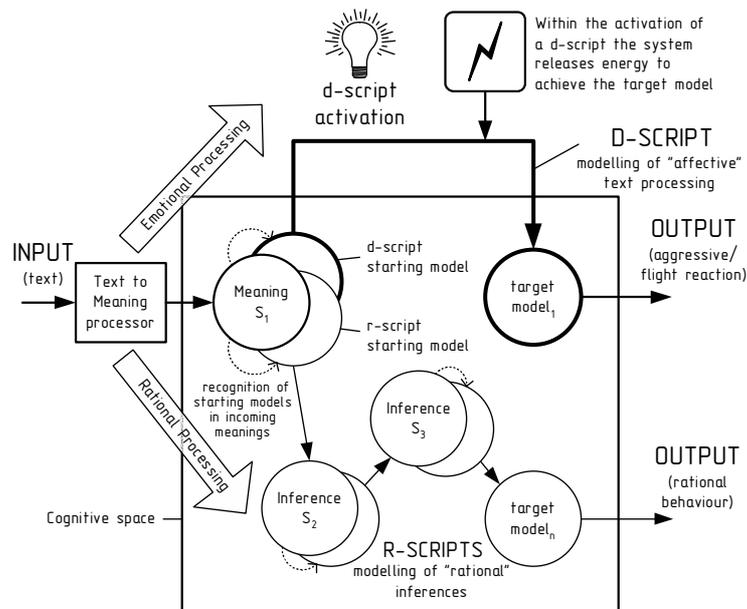


Figure 1. General structure of a model for description of affective text processing

lying to you! and (2) *The mayor thinks only about himself*. The extended scheme, as shown later, will get an opportunity not only to receive utterances and change its state, but also to reply to such utterances and to discuss its internal states. Such kind of affective processing may be parallel (or competitive) to rational processing, so, in our model we arrange units for rational processing – *rational scripts* or *r-scripts* in parallel with units for emotional processing – *dominant scripts* or *d-scripts*. Following [9] we consider, that the units, responsible for simple, emotional processing dominate during the information processing, which motivates the chosen notation. In general case, if some text arrives on the input of the model, its meaning can initiate rational processing – activate r-scripts, or emotional processing – activate d-scripts. If some text is deemed to be affective, it means that in the proposed model it activates at least one d-script. On the other side, if some d-script is activated during text processing, it gives us the right to speak about affective nature of the text (for the “neutral” state of the processor). We show the general structure of the model of Fig. 1.

As shown on the scheme input texts are processed by a Text-to-Meaning processor [5, 19], which is constructing semantic representation – text meaning. Further, the semantic representation launches processing mechanism in cognitive space.

We consider that cognitive space as represented with a number of scripts – if-then operators. Each script has two semantic components: a *starting model (mask)* and a *target model*. A script is activated by a meaning, which corresponds (though not always exactly) to its starting model, and following the activation the script invokes its target model in cognitive space. Thereby an inference chain is represented by a chain of consecutively activated scripts. Scripts represent a number of possible inferences, which can be constructed from each given meaning: for a specific meaning we can point out a list of scripts, which starting models intersect

with the meaning – so, the set of target models of these scripts will give us a number of possible conclusions, which our model can construct.

At this point we arrive to three main problems on scripts functioning, which can be solved in different ways in particular realisations of the model, thus, defining properties of the system: (i) what script is selected out of several candidates, (ii) if one script is selected, should it suppress other scripts activation and (iii) if the starting model of a script doesn’t exactly correspond to initial meaning, how far do we go to check, that there is no significant contradiction in application of this script. These problems are significant for the proposed model, and we briefly return to them later.

As defined, the difference between “emotional” and “rational” processing of meaning is represented by scripts of different kinds: emotional processing activates d-scripts (on Fig. 1 only one d-script is shown), while rational processing activates r-scripts.

A list of 13 d-scripts sufficiently describes the influence of mass media propaganda. For example an utterance (1) *The governments is lying to you!* activates d-script DECEPT (“Deception”) and (2) *The mayor thinks only about himself* activates d-script SUBJV (“Subjectivity”).¹ The proposed inventory of d-scripts, however, doesn’t describe cases of “positive” influence (e.g. advertising) and some types of “negative” interaction in interpersonal communication.

For a simple realisation of the model we can assume, that activation of a d-script completely suppresses activation of r-scripts, in other words, and emotional reaction once started doesn’t permit rational analysis. However, there are evidences in the domain of psychology, that parallel processing and even multi-channel emotional processing of incoming messages is

¹ On the register of d-scripts refer to: <http://www.harpia.ru/d-scripts-en.html>

possible (see., for example, G. Bateson “double-bind” theory with functional analysis of schizophrenia [2]).

Different types of conclusions available for the proposed model can be linked with behavioural reactive actions (not examined here). This link is most evident for d-scripts: if a certain affective meaning irritates the starting model of a d-script, the d-script activates and starts affective reaction. In particular, if our model receives a meaning ‘the government is lying to you’, it activates d-script DECEPT, responsible for detection of deceit, which starts *aggressive* or *flight* reaction. An aggression reaction may result in breaking a window in the government hall or protest voting – for restrained aggression (which is usually desired by the authors of pre-election mass media texts). If our model is wise enough to concentrate on its targets suppressing initial reaction, and can plan its behaviour, we presume, that activation of a d-script constructs a target model in the cognitive space. However, if we deem, that our model is quite simple and pure reactive, we can link each d-script with a specific reaction without any target model. In particular, a simple organism can detect a situation, where somebody is trying to capture its food, and reply with aggressive or flight reaction. In the same sense a human audience of mass media may react on utterances like (3) *The government takes your money* – but humans are able to coordinate their activity and to choose a way of revenge upon the government, which results in protest voting. Models, which have quite sophisticated mechanisms of rational processing (big number and balanced system of r-scripts) may plan its activity in a pure rational way. In this case no emotional processing is included in the processing circuit and the target model for behaviour is constructed only by r-scripts.

The proposed model with distinction of “rational” and “emotional” processing of meaning corresponds to H-CogAff architecture discussed in particular in [9, 10, 11]. H-CogAff model defines three layers of information processing: reactive, deliberative and meta-management. Early organisms and some existing simple organisms are considered at totally reactive and having only reactive layer of processing available, while adult humans have all the three layers of processing. More sophisticated layers of processing – deliberative and meta-management levels – evolve both in phylogeny and ontogeny. Reactive processes in H-CogAff are appended by “global alarm” system which can provide fast reactions upon detection of emergencies or urgent opportunities, suppressing slow deliberative processing. In this respect emotional state is defined in H-CogAff architecture as interruption of ongoing processing [11] and fast reaction, provided by a simple and reliable mechanism of the alarm system. D-scripts, proposed in our model are quite similar to alarm system in CogAff architecture and on the other side – to the concept of protospecialists, as proposed in [6, p. 163-172]. D-scripts in the same way detect “critical” meanings in incoming texts or in results of a preceding inference and initiate affective reactions. At the same time although d-

scripts can model some types of affective speech processing, they cannot serve as functional models of emotions. Here we follow [15], with argumentation that emotions can be described not as a simple reactive processing itself, but also as recognition of some kind of reactive processing.

3. Structure and Functioning of a D-Script

As an example we discuss here one of 13 d-scripts – SUBJV (“Subjectivity”). This d-script is revealed in sentences (4) *You think only about yourself* – for conflict communication, and (5) *The government is concerned only about its salary* – for influence or complaint communication [4].

In fact, we can get angry, if some person who is quite close to us (is our boss or relative) thinks only about himself or about some really useless matter. In we are affected, we can produce utterances in this respect, initiating complaint communication (if we speak with some 3rd party) or conflict communication (if we speak with someone, whose actions affect us). On the other side we can try to affect the listener, reporting to him phrases similar to (5). This speech behaviour is described as initiated by activation of d-script SUBJV or aimed at activation of this d-script of the listener (or both). Starting model of this script describes the situation of ‘subjectivity’ – this semantic component activates SUBJV if found in incoming text. Starting model includes slots AGGR – for person or entity, whose actions seem to be subjective, and VICT – for person, who is affected. As starting model is just a semantic component – it is quite similar to lexical meaning, so it can be defined on a similar metalanguage:

SUBJV(AGGR, VICT, M^S, P_{AGGR}, M^G):
AGGR doesn't consider relevant factors of the situation and is effecting or is going to effect [all the possible] actions P_{AGGR} upon discovering of the stimulus M^S or to achieve a goal M^G; AGGR and VICT are linked with a relation P_{AGGR-VICT}.

There are still some differences between a normal lexical meaning and starting model of a d-script. In emotional texts we can find different meaning shifts and distortions indicating emotionality of the text [18]. In particular a neutral verb “*speak*” may be replaced with a verb with increased intensity (for example – “*shout*”) to mark an implicit aggression of the addresser: *Why do you speak?* – neutral, vs. *Why do you shout?* – emotional [14, 16]. Following several semantic shifts a neutral phrase (6) *The government is working on the budget* may be shifted to (7) *They all always shout only about their budget/such trifles!* We consider that examples like (7) are better recognised by d-scripts during text perception and can be easily constructed in emotional state of the speaker (following activation of the respective d-script). To describe possible semantic shifts we append the definition of each d-script with a list of *critical elements* – semantic markers which value

can be shifted in order to facilitate activation of a d-script in communication. A notion of a “critical element” can be illustrated as follows. If our addressee comes late we can put him to shame by increasing the time of his delay, for example, we can say: (8) *I'm waiting you already for one hour!* (even if we are waiting less). Time-of-delay acts as a critical element if accusing somebody in being late, it can be recorded as **<time of delay>⁺**. The more we shift the time of delay – the more the addressee is ashamed (but if we increase the time too much the addressee can easily falsify our statement – this is the contrary factor). The analysis of mass media and conflict texts gives us a list of critical elements for each d-script. Above all, the following critical elements are relevant to d-script SUBJV:

- <number of AGGR>⁺** e.g.: *Everybody* thinks only about himself!
- <intensity of P_{AGGR}>⁺** e.g.: Why do you start *shouting*, when I mention the washing machine?
- <frequency of P_{AGGR}>⁺** e.g.: My dog *always/constantly* barks at cats!
- <timeframe of P_{AGGR}>⁺** e.g.: He *always* talks about football!
- <inevitability of P_{AGGR} upon the occurrence of M^S>⁺** e.g.: He *definitely has to* bark at each cat!
- <time interval between M^S and P_{AGGR}>⁻** e.g.: When central heating damage occurs, local administration *immediately* declares that this is a fault of the condominium!
- <importance of M^G>⁻** e.g.: *Luzhkov shall bite to death everybody in order to be the first to congratulate Eltsin with his birthday!* (S. Dorenko)
- <inadequacy, naivety of M^G/P_{AGGR}>⁺** e.g.: What can I do if he always *turns the vase up side down?*

We expect that an addresser in emotional state (having activated a d-script) will shift meaning of his text, as defined by the critical elements. Further, an

addresser willing to affect the listener (to activate his d-script) will shift the meaning in the same way, but with better accuracy – for not to make his plan evident to the listener.

We can say that d-scripts may capture meanings, shifting and assimilating them with its' starting models. So, if some meaning seems to be affective, it receives a special representation which is closer to a starting model of a d-script. This corresponds to the thesis, that representations of concepts depend on situations, where the concepts are represented [1, 13]. During the meaning shift the reality specific semantic markers can be omitted (e. g. *government* may turn to *they*) – this is to insure, that addressee will start emotional processing (d-script), but not any type of rational processing (r-script). At the same speaker will express in text the critical elements of the d-script (e. g. *they* may turn to *everybody*, and *discuss* may turn to *shout*). Such meaning shifts may be effected by an addresser in emotional state (an addresser, who has activated a d-script), or by an addresser, who wants to manipulate the addressee, and activate his d-script.

At this point we have to note, that in an emotional state an addresser is less critical to his own texts and less rational in modelling of listener's performance. Under the activation of a d-script he will allow numerous shifts in critical elements, in particular, he will produce utterances like (7), and he would believe, that this utterances are really affective. On the other side, if there are many critical elements, expressed in an utterance with significant exaggerations in each, it becomes quite easy for a listener to recognize in his rational processor the emotional nature of this text, and activate r-scripts instead of d-scripts. In particular, if we receive an utterance (1) *The governments is lying to you!* we wouldn't be immediately affected but we would easily recognize, that there is something wrong with the

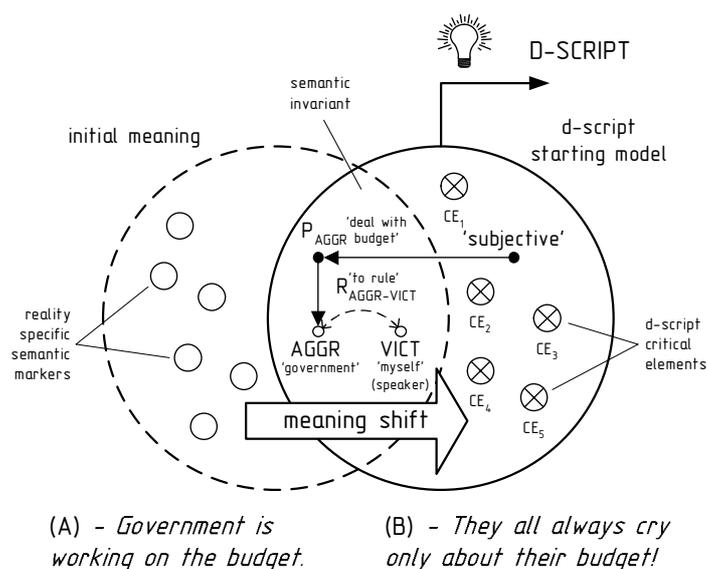


Figure 2. Meaning shift, forced by a d-script activation (emotional state of the speaker), or made with the purpose to activate a d-script of the listener = to affect the listener (the case of speech influence)

Table 1. Expectations of addresser on the distribution of AGGR and VICT slots between the participants of communication

	Addresser	Addressee	3 rd party	Thesis of addresser
1.	VICT	AGGR	–	Conflict: <i>You are concerned only about your football! You, politicians, are only concerned how to speak well!</i>
2.	VICT	–	AGGR	Complaint: <i>My husband speaks only about his football!</i>
3.	VICT	VICT	AGGR	“Communication of victims”: <i>Modern youth think only about dances!</i>
4.	–	VICT	AGGR	Speech Influence: <i>The Government thinks only about their taxes!</i>
5.	AGGR	VICT	–	Aggression: <i>I’m going to kill you!</i> (for d-script DANGER)
6.	VICT/ AGGR	–	–	Self-accusation: <i>I make all the troubles!</i>

speaker: he is either affected himself (and maybe needs our help) or has some plans and wants to manipulate us. There are different ways to suppress such rational reaction of a “wise” listener. In particular, the meaning, corresponding to starting model of a d-script, shouldn’t be evident from the text, but has to be reconstructed with a help of inference or some speech mechanisms. Such speech mechanisms, used for implicit influence is mass media texts, constitute another main object of our studies (see - <http://www.harpia.ru/methods/>).

4. Application of D-Scripts to Different Types of Emotional Communication

Starting model of any d-script contains slots AGGR and VICT. The set of these slots is superimposed on the set of participants of communication: *addresser* and *addressee*. In other words, addresser and addressee can distribute the slots of AGGR and VICT in different ways, and in addition some third party may act as a supposed aggressor (AGGR). On one hand the proposed model activates d-scripts when receiving texts like (9) *Your mother doesn’t tell you the truth* (it will consider itself as a victim - VICT, while 3rd person – *mother* – as an aggressor, AGGR) on the other hand, it can produce texts like (10) *Government is always lying to you!* (when trying to affect the opponent and make him believe, he is a victim of some other aggressor) or (11) *You are always lying to me!* (in conflict communication, where the addressee is believed to be the aggressor). Different types of such distribution give functional base to classify several types of emotional communication, as shown on Table 1. In this table we classify possible distribution of AGGR and VICT slots according to the understanding of the speaker. Listener may accept or not accept this mode of communicative interaction – this would give a base for further variety of communicative types.

We have to note, that line (5) Aggression is not valid for d-script SUBJV. In this type of communication addresser wants the listener to believe, that he (listener) is a victim of the speaker. For SUBJV this mode of

interaction is rather doubtful, but it is quite evident of some other d-scripts, for example – DANGER: *I’m going to kill you!*

Generally the structures of communication, defined in Table 1 were widely investigated in linguistics and psychology. In particular, Eric Berne has described so called here “communication of victims” (line 3) as a type of interpersonal interaction – a “game” «Ain’t It Awful» [3].

5. Speech Synthesis by Different Components of the Model

A normal dialogue simulation for “communication of victims” or “speech influence” would pass as follows:

- the system accepts on input an indication of 3rd party hostile or neutral actions, like (6) *The government is working on the budget* (neutral) or *The government always shouts about the budget* (affective);
- the system activates a d-script (which is closer to the accepted meaning) and shifts the meaning according to the list of critical elements, defined for this d-script;
- shifted meaning is used for text synthesis.

This procedure provides the simulation of dialogues like:

- *The government is working on the budget.*
- *They all always shout only about their budget/such trifles!*

Dialogues of this type can represent “communication of victims” or successful “speech influence” – in both cases the speaker considers some 3rd party is AGGR and the listener shares this conceptualization. However, in general case a communicative (or denotative situation) may give no allusion to the listener to how it should be treated, therefore it can activate different d-scripts of the listener with different distribution of valencies. In particular, speaker may accuse his opponent – *You are concerned only about your football!* (Addressee=AGGR), or accuse himself of some harmful situation – *I make all the troubles!* (Addresser=AGGR).

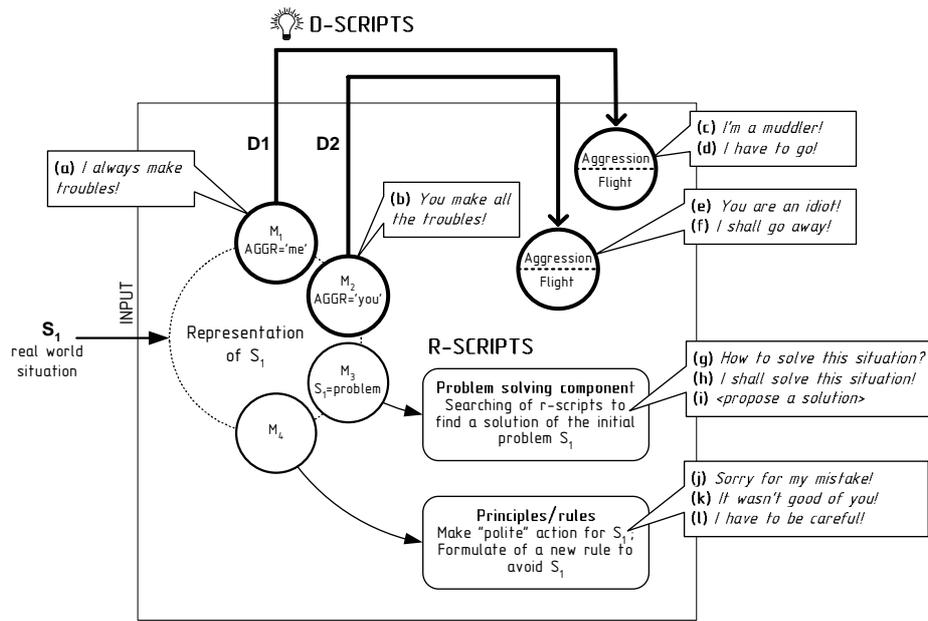


Figure 3. Processing of the initial representation and text synthesis by processing components

For an interpersonal emotional communication (where no active 3rd party is designated) we can indicate several typical emotional speech reactions, described by the d-scripts structure (as shown of Fig. 3). As an example of emotional interaction we can discuss situations where the system (speaker) did some harm to the listener, or where the listener did some harm to the system. A basic classical set of such situations is represented in S. Rosenzweig picture frustration test (PFT) [8] – which is used as a base material for studies.

As shown on Fig. 3 the emotional situation S_1 receives (through observation or through text analysis – in case of text input) a representation in the cognitive space. This representation may correlate with starting models of d-/r- scripts and start emotional/rational processing with subsequent speech reactions.

First, the system may blame itself for improper actions. In this case, it activates d-script D1 where it treats itself as AGGR. Starting model of D1 may result speech output, falling in class (a): *I always make troubles!* Other utterances of this class would contain as a semantic component starting model of a specific d-script (*I always lie! I don't care even about my best friends!* etc.) and would experience semantic shifts, as defined by critical elements for this specific d-script. The same d-script D1 may bring the system to target models of aggression or flight and before these models are executed in action they can be expressed in utterances of classes (c) and (d).

Second, the system may treat the representation of S_1 as model M_2 , where the addressee=AGGR. For the d-script D2, activated by M_2 , the system will accuse the addressee (b), report aggressive actions or swear (e), or report flight behaviour due to addressee's actions (f).

The system may treat initial emotional situation S_1 as a problem, requiring a rational solution, which is processed by problem solver. The function of the problem solving component is to define the initial problem situation (which is usually equal to S_1), define the situation when the problem is solved, and search for r-scripts to bring the initial problem situation to the solution [7]. Operation in this component may also result emotional processing and activate d-scripts, when the solution is deemed to be impossible – *There is nothing I can do here! Everything is useless!* To assuage the listener the system may also report, it knows the solution (h), or in other cases – address the listener to request a solution (g).

The system may follow diverse rules, fixed by social regulations, etiquette or personally invented for particular situations. In case the system makes harm to the listener – it may follow the rule 'to make excuses' and produce on output "polite" utterances for this particular situation (j). With the help of rules component the system may detect, that the addressee violates the rules and indicate that in speech (k) – this violation may indicate 'inadequacy' or 'subjectivity' of addressee and start the corresponding d-script, combining affective and rational processing. Further, the system may formulate a new rule for itself or for the addressee in order to avoid negative situations S_1 – representations of such rules in speech refer to class (l).

We presume that selection of a particular class of utterance is subject to different psychological and linguistic factors. The description of such factors as well as quantitative analysis of output for each class in different conditions constitute one of the most interesting present research tasks for this theory.

6. Conclusion and Future Work

In the present issue we have represented a general architecture of a cognitive system for processing of affective meanings and for simulation of synthesis/analysis of affective speech. We have defined, that affective processing is performed by specific components of the model – d-scripts. D-scripts apply to different types of emotional communication and define meaning shifts and selection of semantic components to appear in affective texts.

The project of studies of d-scripts: analysis of their starting models, lists of critical elements and their typical realizations is available on the internet at:

<http://www.harpia.ru/d-scripts-en.html>

We expect, that the development of the model would make possible to construct computer agents, simulating synthesis of emotional speech for given situations and responding “emotionally” on affective texts. Such agents may be built into home appliances, vehicles, information terminals and computer interfaces in order to implement emotional communication with the user for amusement purposes or where it would simplify communication and user’s understanding.

One of the most important areas of further studies is the search of dependency between linguistic and psychological models of emotions in interpersonal communication. We expect that certain emotional states and personal characteristics (described by psychological models) may change the preferences on the selection of d-scripts, resulting in different speech output. The studies are presently carried out with Vygotsky Institute of Psychology (RSUH, Moscow).

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