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Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 18(0)

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Publication Date
1996

Peer reviewed

The Evaluation of the Communicative Effect

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Abstract

Aim of our research is an analysis of the inferential processes involved in a speaker's evaluation of the communicative effect achieved on a hearer. We present a computational model where such evaluation process relies on two main factors which may vary according to their strength: 1. the verbal commitment of the hearer to play his role in the behavioral game actually bid by the speaker, 2. the personal beliefs of the speaker concerning hearer's beliefs. The hypothesis was tested as follows. First, we devised a questionnaire in order to collect human subjects' evaluations of communicative effects. Subjects were required to consider some scenarios and to identify themselves with a speaker. Their task was to evaluate, for each scenario, the communicative effect they had reached on the hearer (acceptance to play the game, refusal, or indecision). Then, we implemented our computational model in a connectionist network; we chose a set of input variables whose combination describes all the scenarios, and we used part of the experimental data to train the network. Finally, we compared the outputs of the network with the evaluations performed by the human subjects. The results are satisfactory.

1. Introduction

The reason why a speaker communicates is to reach an effect on a hearer. However, the psychological literature is not much concerned with an analysis of the communicative effect, i.e. perlocutionary effect. Our research is an attempt to analyze the perlocutionary effect from the point of view of the speaker. In particular, we are interested in *what* is relevant to the speaker in order to evaluate the effect reached on the hearer, and *how* the evaluation process is carried on. In what follows, we claim that the speaker takes into account, as pertaining evidence, both the engagement of the hearer to play the game, and hearer's beliefs on the sincerity of the speaker. The evaluation process, we argue, consists in use of the evidence to strengthen or weaken the belief concerning the effect reached on the hearer. The entire process, which in human beings seems to be speedy and effortless, is modeled by a connectionist network.

The paper is organized as follows. Section 2 is devoted to a brief presentation of Cognitive Pragmatics Theory, with special reference to the mental representations involved in the evaluation of the communicative effect. Our model is introduced in section 3, whereas section 4 is concerned with the questionnaire. The network is described in section 5, and the results of the comparison between human subjects' performances and the performances of the network are given in section 6. Finally, conclusions are in section 7.

2. Cognitive Pragmatics Theory

Cognitive Pragmatics Theory is concerned with an analysis of the cognitive processes underlying human communication. The theory, advanced by Airenti, Bara and Colombetti (1993), is presented inside the framework of Speech Acts' Theory and, consistently, claims that communication must be considered part of action (Austin, 1962; Searle, 1969, 1979). Indeed, when actor A communicates, either verbally or not, she aims at reaching an effect on partner P by means of changing his mental states or inducing him to perform an action. Given the assumption that the same analysis holds for both verbal and nonverbal communication, the terms actor and partner are commonly used instead of the terms speaker and hearer. Following the convention, we'll also refer to actor A as a female and to partner P as a male.

One of the major assumption of Cognitive Pragmatics is that, in order to cooperate from the behavioral point of view, the actor and the partner must act on the basis of a plan at least partially shared, that is called *behavior game* between A and P. Consider, for instance, the following example.

(context: a client enters in a shoe-shop)
[1] A: I'm looking for a pair of green shoes.
P: Sorry, but they were all sold out last week.
A: Well, I'll have a look elsewhere. Thanks.

An oversimplification of the behavior game shared by A and P in [1] is the following:

[2] [BUY-SOMETHING]
1. P gives an object x to A
2. A gives an amount of money y to P

A behavior game is a stereotyped pattern of interaction where the moves of A and P are specified and indicate the type of contribute that each of them is expected to provide at a certain point of the game in order to be cooperative. The moves need not be logically necessary as they just describe typical interactions involving the agents. Besides, the game specifies the situation in which the game can be played by the agents, namely its validity conditions. In our example, the game will also specifies that one must ask for an article in the proper shop, e.g. A will not ask for a pair of shoes in a bakery, and will pay the amount required for the article, e.g. A will not pay $5 if the shop assistant declares a price of $60.

The relevance of the notion of behavior game relies on the fact that, according to Cognitive Pragmatics Theory, a speech act realizes a move of a behavior game. Therefore, it is claimed that, in order to deeply understand the communicative intention of an actor, the partner must realize what game she bids by means of the utterance. In particular, Airenti and colleagues analyze the process of comprehension of a communicative act and theoretically decompose it in five phases:

1. *Literal meaning*. The partner reconstructs the mental states literally expressed by the actor.
2. *Speaker's meaning*. The partner reconstructs the communicative intentions of the actor.
3. *Communicative effect*. The partner possibly modifies his own beliefs and intentions.
4. *Reaction*. The intentions for the generation of the response are produced.
5. *Response*. An overt response is constructed.

In phase 2 all the relevant communicative intentions of the actor are reconstructed by the partner; their relevance is established on the fact that they manifest the actor's intention to participate in a behavior game with the partner. Thus, the utterance proffered by A is really understood when it is referred to the behavior game bid by A. For instance, an utterance like :

[3] A: Can you rise your arm?

may be interpreted by P as a request to rise his arm or as a request about his possibility to rise the arm. If the behavior game suggested by the context is [AT THE TAILOR'S] the intended meaning might be a request. On the other hand, if the game suggested by the context is [MEDICAL EXAMINATION] the actor's meaning might be a request concerning the physical possibility that P rise his arm.

Our research attempts to model part of the communicative process as it is described by Airenti and colleagues, namely A's evaluation of the communicative effect reached on P. In terms of game bidding and acceptance the communicative process can be analyzed as follows :
i. A bids a game to P
ii. P responds
iii. A evaluates if P adheres to the game.
Indeed, A's comprehension of the response produced by P can in turn be theoretically analyzed in the phases outlined by Airenti and colleagues. P's response is a starting point for A's reconstruction of his intention to play the game.

3. The computational model

The evaluation of the perlocutionary effect consists in a reasoning process where, according to Cognitive Pragmatics, two factors play a major role.

First, A has to take into account the engagement of P to play the game. In particular, the engagement to play a move of the game may be considered an acceptance of the game itself. But, obviously, this is not sufficient to account for the evaluation of the perlocutionary effect. It is still possible, for instance, that P lacks of confidence in A. If A believes that this is the case, she may think to have not reached the intended effect, even when P expresses the intention to play the game. Possibilities of this type may account for deceits in communication.

Thus, the second factor involved in evaluating the perlocutionary effect is the set of beliefs concerning the mental states of the partner. In our computational model the beliefs of A concerning P's beliefs play a major role in the evaluation of the communicative effect. Note that the notion of shared knowledge we borrow from Cognitive Pragmatics is a one-sided definition. Since we are concerned with the mental representations of A, it would be the case that:
i. A may take for shared the knowledge that P does not believes to share with her. In particular, A's and P's representations of the behavior game that A is bidding may be different.
ii. A may erroneously attribute certain beliefs to P.

In our computational model the attribution of beliefs to the partner heavily influences the evaluation of the perlocutionary effect, as much as the verbal or nonverbal commitment of the partner to play the game. We refer to the evaluation process as *evidential reasoning*. Indeed, each of the possible evaluations (P accepts the game/P does not accept the game/it is not clear whether or not P accepts the game) is strengthened or weakened on the basis of the evidence. In our model, beliefs concerning partner's beliefs and partner's commitment to play a game are the evidence sought by the actor to evaluate the acceptance of a game. The weight of a given piece of evidence determines how much it should strengthen or weaken the belief that a partner has accepted to play the behavior game.

The cognitive science paradigm dictates three steps for the validation of a computational model. First, the implementation of the model in a program; second, an experiment carried on human subjects and, third, the comparison between the performance of the program and those of the human subjects. As we implement our model into a connectionist network we face the problem of how to use the experimental data. Indeed, in a classical Artificial Intelligence program the computation is completely defined from the beginning, and the experimental data are used just for the comparison with the outputs of the program. On the contrary, a connectionist network is, in principle, general purpose and needs be trained on the experimental data to adapt to a specific task. Thus, we collected human subjects' evaluations of perlocutionary effects both to train the network to evaluate perlocutionary effects, and to observe the fitting of the evaluations of the network with those of the human subjects.

The next section is devoted to the questionnaire we administered to the experimental subjects.

4. The questionnaire

Subjects

Twenty-four undergraduates students of Turin University. They were balanced according to their gender.

Materials and Procedure

Subjects were presented individually with the questionnaire in a quiet room. At the very beginning they were told to read the following instructions:
"Read carefully the story I'll give you, and try to identify yourself with the actor. After reading the story, your task will be to evaluate possible courses of a specific situation. In particular, for each course, you are asked to evaluate whether your partner accepts your proposal to have dinner at home tonight. Possible evaluations are: 'yes' (YES), 'no' (NO) or 'It is not clear' (?). Your evaluations must take into account the story and the information concerning the specific course of the situation."

The story tells about the relationship of the actor A (the experimental subject) with her partner P. In particular, it specifies one of the following relationships: confidence, mistrust and uncertainty about confidence. The questionnaires were balanced according to the three types.

Besides, the story tells about a particular situation of everyday life involving the actor and the partner. For instance, let us consider the story as it is presented to a female experimental subject, where the name of the partner is Paul:
"You and Paul usually have dinner together, sometimes at home, sometimes at a restaurant. When you decide for a home-dinner you are not satisfied with a hot-dog in front of the television; dinner is a rite for you and the table must be laid in the appropriate manner.
Paul is very good at cooking, whereas you are a disaster: you usually attend to buy food.
Now it's 7.00 pm and Paul cannot go out to buy food since he is waiting for a phone call. The table is not laid and you tell him: "I'm going for shopping, but I will not lay the table".
Information concerning possible courses of the situation specify:

i. the engagement of the partner to cook and to lay the table (engagement, no engagement, refusal to engage).
E.g., 'Paul says that he will cook, but he does not intend to lay the table'.

ii. the beliefs of the partner concerning the effective intentions of the actor to buy food and not lay the table (sincerity, uncertainty on sincerity, insincerity).
E.g., 'Paul believes you are sincere when you say that you will buy food and not lay the table.

5. The network

We implemented the model in a Radial Basis Function Network (RBFN). RBFNs are a well-known class of networks that, given a set of samples, approximate an unknown target function. They naturally exhibit symbolic properties (Blanzieri & Giordana, 1995). The RBFN architecture approximates a target function with a weighted sum of receptive field functions (hypergaussians). Such functions are local in that the points of the input space which activate each of them belong to a local area. The weight of each receptive field can be seen as an output value associated to its own local area. The associations between the local areas and the output values can be translated into a production rule of the type:
if <the input is inside the local area of activation>,
then <the output is the one suggested>.
Via this property it is easy to extract symbolic knowledge from the network. The network computes the average of all the activated rules. Thus, the rules are not completely equivalent to the network, rather, they are symbolic representations of the information encoded into it. In our model, the target function is the actor's evaluation of the adherence of the partner to the game. The function depends on the response of the partner and on his beliefs about the sincerity of the actor.

Our network has three layers: five input units, one output unit, and five hidden units, i.e receptive fields. The five input units correspond to the input variables that describe the scenarios presented to the subjects (Figure 1).

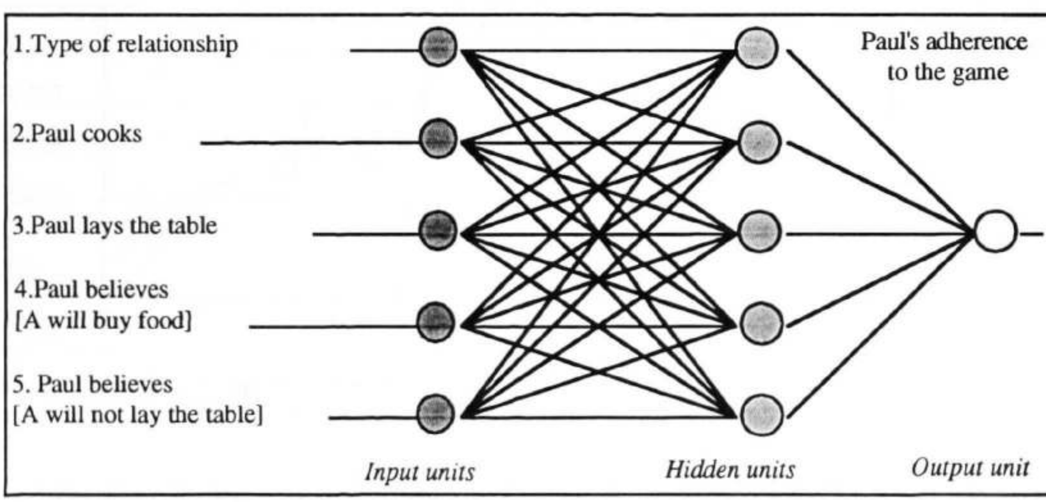

Figure 1. The architecture of the network.

The value of input 1 refers to the relationship between A and P: confidence (1), mistrust (0) and uncertainty about confidence (0.5).

The values of inputs 2 and 3 refer to the fact that P has expressed the intention to play a specific move (value 1), not to play the move (value 0), or he is uncertain (value 0.5).

The value of inputs 4 and 5 refer to the attendibility of A's engagement to play his move from P's point of view, as represented by A. Value 1 means that A believes that P believes that A intends to perform the declared move (sincerity). Value 0 means that A believes that P believes that A does not intend to perform the declared move (insincerity). Value 0.5 means that A believes that P believes that A is not reliable, namely A may or not perform the declared move (uncertainty on sincerity).

The output unit represents the actor's evaluation of the degree of adhesion of the partner to the game; he adheres (value 1), he does not adhere (value 0) or his adhesion is uncertain (value 0.5).

The number of units of the hidden layer coincides with the number of production rules. A number of hidden units higher than necessary leads to a poor generalization, i.e. overfitting. If this is the case, the network performs well on the training data set, but has poor performances on the remaining data. On the other hand, a poor number of hidden units prevents the learning. The network with the optimal number of hidden units performs better than the others.

Our experimental data base contains 486 couples scenario/actor's evaluation. The three different types of evaluation occur as follows: adhesion to the game 31.7%, no adhesion 38.5% and uncertain adhension 29.8%. We adopted the method of randomly select a population of 20 pairs of training and test sets (2/3 and 1/3 of the couples respectively). Then, we verified the generalization performance for each test set on networks containing different number of hidden units (ranging from 4 to 8). The results show that the network with 5 hidden units performs better than the others. The difference is statistically significant (Wilcoxon Test, $p < .05$). Finally, we trained a network with 5 hidden units on the overall data.

6. Comparison between subject's evaluations and network's outputs

The trained RBFN is a functional expression of part of the actor's knowledge of the behavior game.

We presented the network with the 81 scenarios which were presented to the experimental subjects, and we collected 81 different outputs. The output of the network ranges from 0 to 1. We considered as evaluations of adherence to the game the outputs with a value greater than 0.66; as no adhesion the outputs with a value lower than 0.33; as uncertain adhesion the outputs with a value ranging from 0.33 to 0.66.

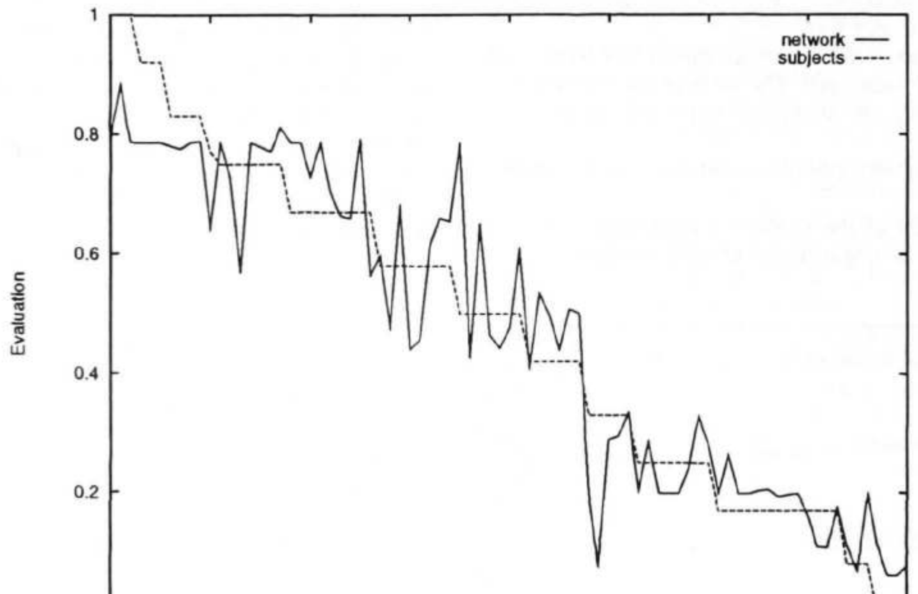

Figure 2. The chart shows, for the 81 scenarios, the outputs of the network (continuous line) and the average values of the subjects' evaluations (dashed line).

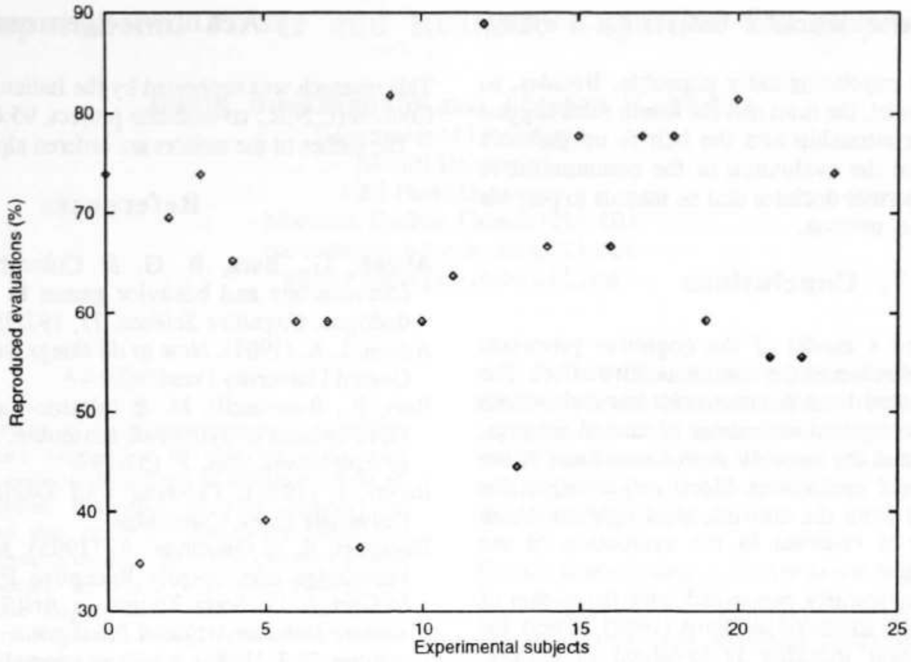

Figure 3. Percentages of evaluations reproduced by the network for each of the 24 experimental subjects.

First, we present the global results concerning the comparison between overall subjects' evaluations with respect to all the scenarios and the evaluations performed by the network. As each evaluation involves the selection among three alternatives the probability of chance-guessing the evaluation of the experimental subjects is .33. As a matter of fact, the correct prevision rate of the network is 63.7 %. The chart in Figure 2 visualizes the approximation capability of the network.
Second, we compare the evaluations of each subject with those of the network (see Figure 3). Results show that the network reproduces more than 50% of the evaluations of 20 subjects. The network does not predict the evaluations of the remaining 4 subjects.

Finally, the rules extracted from the network are summarized in the Table 1.
As an example, the 5th rule reads as follows:

If the type of relationship is confidence,
P says that he will not cook,
it is uncertain if P will lay the table,
P believes that A will not buy the food,
therefore P does not accept to play the game.

	Rule 1	Rule 2	Rule 3	Rule 4	Rule 5
1. Relationship	Confidence	Mistrust	About confidence	Mistrust	Confidence
2. P cooks	About yes	Yes	Yes	Irrelevant	No
3. P lays the table	Yes	Irrelevant	No	No/uncertain	Uncertain
4. P believes [A buys food]	No	Uncertain	Irrelevant	Uncertain	No
5. P believs [A lays the table]	Irrelevant	Uncertain	About yes	About no	Irrelevant
Paul's adhesion to the game	About yes	Yes	About no	No	About no

Table 1. The rules extracted from the network. The term 'irrelevant' indicates that the value of a variable does not affect the activation of the rule.

Note that it is irrelevant whether P believes that A will lay the table or not.
The five rules are psychologically plausible. Besides, as predicted by our model, the third and the fourth rules suggest that the kind of relationship and the beliefs on partner's beliefs do influence the evaluation of the communicative effect, even if the partner declares that he intends to play his role in the game, i.e. to cook.

7. Conclusions

We have presented a model of the cognitive processes involved in the evaluation of the communicative effect. The model is implemented by a connectionist network whose performances are compared with those of human subjects. The results show that the network reproduces most of the experimental subjects' evaluations. Moreover, we argue that the rules extracted from the network shed light on which kind of evidence is relevant in the evaluation of the communicative effect.

Our model is particularly concerned with the notion of thinking about beliefs advanced by Baron (1988). Indeed, the author suggests that thinking is involved in beliefs' formation, namely when people think to decide how strongly to believe something, or which of several competing beliefs is true. In this process, *evidence* consists of any object that helps them to determine the extent to which a possibility achieves some goal. We argue that the concept of evidence is particularly suitable to describe the inferential processes involved in communication, where inferential bounds are built with speedy and effortless. Whereas symbol manipulation seems to account for children and adults ability to draw formal inferences (see, for instance, Bara, Bucciarelli and Johnson-Laird, 1995), it is possible that explicit knowledge is not required in dealing with the evaluation of the perlocutionary effect: the brain may use implicit representations, which are based on a parallel distributed process.

Connectionism postulates distributed representations very different from static symbolic representations, and the dynamics of the system owes more to statistical mechanics than to logic. Nevertheless it may be that these representations and the dynamics which transforms one such representation into another can form the basis of a theory of inference (Levesque, 1988; Oaksford & Chater, 1993). As far as our aims are concerned, a relevant feature of connectionist networks is flexibility: our model deals with flexibility as it claims that the actor's beliefs may vary according to their strength, therefore resulting in possible different evaluations of the communicative effect.

We conclude that a connectionist model may give an account of the cognitive processes involved in the evaluation of the perlocutionary effect. It is plausible that human beings are endowed with mechanisms that allow to weigh evidence collected in the light of specific behavior goals. Such mechanisms would underlay the ability to draw inferences in communicative exchanges.

Acknowledgements

This research was supported by the Italian National Research Council (C.N.R., co-ordinate project, 95.04019. CT11).
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