The theory of meaning in communication as a game theoretical incentive for coordination

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Abstract: The main goal of this paper is to analyze the utility of conventions in relation to language and communication. Philosophy of language has provided us with many concepts useful for decoding the meaning of linguistic objects. Linguistics itself is a broad field of science, which lists the functions of language and aims in describing the communication process in order to boost its effectiveness. As I am to present some remarks about how can linguistic content be used as a strategy, I feel obliged to provide a brief introduction into the topics of communication and evolutionary games theory. I will also list basic language functions and tools used in the theory of games for achieving coordination between players. Some very helpful ideas, like the concept of convention (including social convention), shall also be delivered.
However we failed to detect the solid bases of language origin[1], linguistics shaped a simplified definition of language that is widely agreed on. Language is a system of arbitrary symbols for encoding and decoding information using grammar[2].
Labelling the language as a tool, whose only purpose of existence is to fulfil the goals stated by its functions, does not deprive the language of its dignity and importance. Since its very emergence, the language has proven too basic a tool to be discredited, and so unavoidable and to some extent default for all mankind.
Regardless of the ontology one fancies, language is the only reliable means of carrying the essence, structure, meaning or information about any object or abstract concept towards the second party without putting forth the object itself. And so we use the linguistic system successfully as long as we do not find that the meanings we try to mutually communicate fail to match.
As the science of language has abandoned prescriptivism long ago, new ways of compromising the meanings had been searched for. As we see later on, convention and games theory are capable of eliminating the inconsistencies of our understanding in everyday language.

1. Verbal communication, the functions and levels of language.

Communication is simply a process of transferring information from one entity to another. In verbal version, it is conducted by using speech. For the sake of argumentation, I would like to limit the functions of language to bases mentioned by Karl Popper. According to his theory about the emergence of language, we can distinguish four functions, two of which are elementary and believed to have come chronologically as first.

(4) argumentative function (3) descriptive function	validity/invalidity falsity/truth
(2)signal function (1)expressing function	efficiency/inefficiency revealing/ not revealing

Language functions and their criteria according to Popper[3]

It is not my intention to determine whether games theory can help to improve the advanced (3, 4) functions as such. Falsity and validity have essentially little to do with communication

[1] Several plosive possibilities are taken into consideration - here some short description of yo-ho-ho and other funny names. None of them, however, is reliable enough to cross out others.
[2] Universal grammar (Chomsky, Bickerton)
[3] source

efficiency. Rather than that we should concentrate on signaling and expressing, as those are areas where we can say much about the role of strategic coordination. Signaling and expressing are also necessary elements of description and argumentation, as it seems impossible to have (4) and (3) without employing at least one of (2) and (1).

(Here I will present two or three different models of communication i.e. Shannon and Weaver etc.)

It is crucial to notice, that when communication comes into perspective all aspects of language are of importance. Therefore we consider all stages of communication: articulatory, acoustic and auditory one. Also when it comes to noises, the elements that harm successful communication process, the risk occurs at the phonological, phonetic and also morphological or any other level alike.

2. Games theory and meaning

To acquire how games theory can be helpful within improving communication process, one needs to introduce the definition of strategy, coordination game and evolutionary games theory.

Strategic game, in its gametheoretical sense, is such an interaction between participants that includes mutual awareness of the cross-effect their decisions are to bring[4]. Most interesting aspect of this interaction for those who find interest in games strategy is this awareness itself and the fact that player's decisions are taken accordingly to this knowledge.

(Here: Nash equilibrium, pure strategy and payoffs)

Coordination games are those in games theory which have multiple pure strategy Nash equilibria and serve as a formalization of coordination problem. As two examples of such class of games so called battle of sexes (conflicting interest) and pure coordination strategy can be named. In each case two players (employing two independent strategies) make the decision of whether to go to the party or stay home. Both of them would like to spend time with the other, so they get the outcome of (0,0) if their choice differs. Classic battle of sexes is the situation in which players get different outcomes for the same choice, depending on whether they go to the party or stay home. Pure coordination consists mainly of the problem of coordination connected with information transfer. The intention and the payoff matrix for both participants are identical.

[4] Dixit, Skeath, 1999. Games of strategy

P1/P2	Party	Home
Party	10,5	0,0
Home	0,0	5,10

Conflicting interest strategy

P1/P2	Party	Home
Party	10,10	0,0
Home	0,0	5,5

Pure coordination strategy

As we can see, the main difference comes down to the payoffs' value in pure strategies. Communication intends in establishing possibly closest meaning for both, sender and receiver, which is why we can consider it to be the game of pure strategy.

One thing that should be explained before the analysis of communication game is the problem of arbitrariness of linguistic signs. Some may say that due to this unavoidable feature the use of language cannot be considered a strategy. As strategy is a set of options, which are chosen in accordance with the principle of rationality it is never fully arbitrary. But so is not the communication. Despite the fact that sings themselves carry no real information, assigning meaning to them is a matter of society in general. This social relation is often called a convention.

(introduction of evolutionary games theory)

3. Coordination possible. Convention.

The question which arises here is the following: what is the role of convention in communication game? In 1960 Thomas Schelling[5] established the idea of gametheoretical solution for players who cannot communicate to improve their coordination. Such a solution is the one people will tend to chose, as it seems natural, special or relevant to them. This concept is what we call Schelling point or focal point. Depending on the scale of audience we take into consideration, diversity of possible focal points finds validity for the success of communication process, ranging from the idiosyncrasies between two individuals to social conventions that rule messages directed to larger groups or receivers unfamiliar to the speaker.

In his *Enquiry Concerning Human Understanding* David Hume[6] formed a definition of social convention as the sense of common interest, well-known to all members of society. In his view, convention is a useful tool used for the benefit of its participants, which is to some point default, as each member of society expects others to make use of it. The first famous implication of

[5] The Strategy of Conflict
[6] Enquiry, ca p.250

Humean notion into games theory was the initiative of David Lewis[7], who defined convention as follows:

A regularity R in the behaviour of members of population P when they are agents in a recurrent situation S is a convention iff it is true that it is a common knowledge in P that, in any instance of S among members of P following presuppositions are present:

(1) everyone conforms to R and (2) expects everyone else to conform to R; (3)everyone has approximately the same preferences regarding all possible combinations of actions; (4) everyone prefers that everyone conform to R on condition that at least all but one conform to R; and (5) everyone prefers that everyone conform to R' on condition that at least all but one conform to R'.

R' is such a possible regularity in behaviour of P in S that no one in any case of S could conform both R and R'.

Lewis' model allows no exception from conventions and shows general imperfections when considering applying it into linguistic communication. Lewis, however, helped some of those in his work *Conventions*, which developed a two-sided signaling problem between a sender and a receiver that can only be solved by *common knowledge* of both. Lewis aims in explaining the emergence of language by analyzing the game of a communicator and his audience. Also the semantic content is supposed to have come to being in a way that is based at some main conditions .

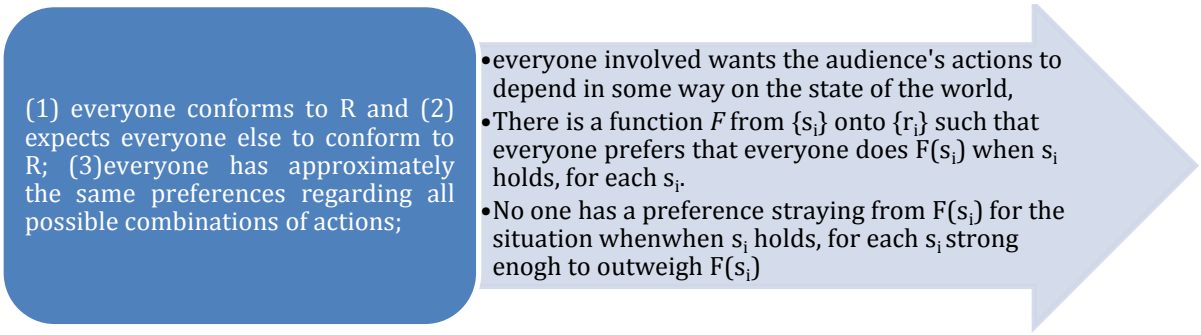
A simplified model of two-sided signaling system omits the problem of noises[8] and declares that there is a limited amount of possible states of affaires, say $s_1,\ldots,s_n$. The sender is the one who recognizes the state of the world and finds the most effective signal to communicate it to the receiver. Receiver, on the other hand, has a set of responses at his disposal, as his reaction depends on one-to-one function, which is ready for him to use like a strategy. Here Lewisian simplified model presumes that there is only one best response to the state of the world and moreover that everyone taking part in the game would agree that it is so. There must also be only one best signal for every state of affaires etc. And so, if n=2 the possible of the set of responses would be:

1. $s_1 \rightarrow r_1, s_2 \rightarrow r_2$
2. $s_1 \rightarrow r_2, s_2 \rightarrow r_1$

[7] source
[8] About the noises

The number of actions that can be taken by a sender must always be more or equal to the number of possible states of affaires. Those actions are signals $\sigma_1,\ldots, \sigma_m$ ($m \geq n$). The receiver is the one to identify which signal was used.

It is crucial that no one participating in this game has any preference regarding signals and responses that is plosive enough to change the function $F(s_1)$ on condition that s_1 holds, for each s_1. The two rules of conformity used in Lewis' previously described model are also present in this game.



Contingency plans are another very important elements for the process of communication. For each party, sender and receiver, there is a way of possible dependence of signal (sender) or response (receiver) on the state of affaires or the signal.

F_c is a function from $\{s_i\}$ into $\{ \sigma_k\}$ and F_a is a one-to-one function from part of $\{ \sigma_k\}$ into $\{r_j\}$. Whenever F_c and F_a combine to deliver the preferred response of the audience (receiver) to the state of affaires, signalling system $< F_c , F_a >$ comes into perspective.

The outcome of the game is always a mixture of strategies (here: contingency plans) of a sender and a receiver. It is logically possible for a sender to assign the same signal for more than one state of affaires. This means that, although it is not rational for him to do, sender could possess two signals and two states of affaires and have them form not two, but four possible strategies instead:

1. $S1 \rightarrow \sigma1, S2 \rightarrow \sigma1$.
2. $S1 \rightarrow \sigma1, S2 \rightarrow \sigma2$.
3. $S1 \rightarrow \sigma2, S2 \rightarrow \sigma1$.
4. $S1 \rightarrow \sigma2, S2 \rightarrow \sigma2$.

Here, evolutionary game theory complements Lewisian model by allowing the same strategy for a receiver:

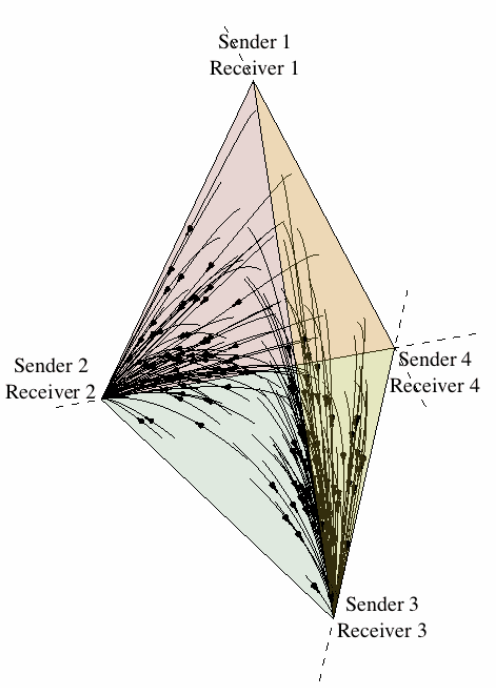
1. $\sigma 1 \rightarrow r1, \sigma 2 \rightarrow r1$.
2. $\sigma 1 \rightarrow r1, \sigma 2 \rightarrow r2$.
3. $\sigma 1 \rightarrow r2, \sigma 2 \rightarrow r1$.
4. $\sigma 1 \rightarrow r2, \sigma 2 \rightarrow r2$.

If we assume that the roles of a sender and a receiver are mutually interchangeable[9], we can form 16 possible strategies for both players:

Player 1: (Sender 2, Receiver 2), Player 2: (Sender 2, Receiver 2)
Player 1: (Sender 3, Receiver 3), Player 2: (Sender 3, Receiver 3)
Player 1: (Sender 2, Receiver 3), Player 2: (Sender 3, Receiver 2)
Player 1: (Sender 3, Receiver 2), Player 2: (Sender 2, Receiver 3)

First two are here evolutionary stable strategies, as changing the signal system for a sender and a receiver e.g. making them speak two different languages would hardly work if we randomly chose the players from all the populations.

Alexander J. McKenzie presents the model of state space under continuous replicator dynamics limited to four strategies: (Sender 1, Receiver 1), (Sender 2, Receiver 2), (Sender 3, Receiver 3), and (Sender 4, Receiver 4). The consequence of the evolution is that the population in almost all cases converge to one of the two signaling systems.



[9] stanford

'Hofbauer and Hutteger[10] (2008) show that, quite often, the replicator dynamics will converge to a suboptimal outcome in signalling games. In these suboptimal outcomes, a pooling or partial pooling equilibrium will emerge. A pooling equilibrium occurs when the Sender uses the same signal regardless of the state of the world. A partial pooling equilibrium occurs when the Sender is capable of differentiating between some states of the world but not others. As an example of a partial pooling equilibrium, consider the following strategies for the case where N=3: Suppose that the Sender sends signal 1 in state of the world 1, and signal 2 in states of the world 2 and 3. Furthermore, suppose that the Receiver performs action 1 upon receipt of signal 1, and action 2 upon receipt of signals 2 and 3. If all states of the world are equiprobable, this is a partial pooling equilibrium. Given that the Sender does not differentiate states of the world 2 and 3, the Receiver cannot improve his payoffs by responding differently to signal 2. Given the particular response behaviour of the Receiver, the Sender cannot improve her payoffs by attempting to differentiate states of the world 2 and 3'.

4. Conclusion

General idea of using replicator dynamics for improving communication can fail mainly when the system extends and users are not assigned to certain role (receiver or sender). This means that whenever we aim in connecting a certain meaning with the message we must limit the elements of the game as much as it is possible. The problem does not seem so serious if we use the state space under continuous replicator dynamics as a means of finding possible interpretations of signals. Probability, as a crucial matter of interpretation, is also a key term for understanding the concept of focal points.

One of the weak sides of those concepts, all based on evolutionary game theory is the hardly possible application with the necessity of estimating data for each and every case, when the number of players exceeds two or three, let alone assigning the states of the world to signals and responses.

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