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## The Evolution of Meaning in a Game-Theoretical Setting Cognitive Constraints and Experimental Architecture

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### Project Description

Language is an object of study in many scientific disciplines. There are the theoretically oriented disciplines of linguistics, logic, and philosophy of language. There are the empirically oriented fields of cognitive psychology, psycholinguistics, and biology. And there is artificial intelligence, opening the way to a more experimental approach.

A central notion studied in all these disciplines is the notion of ‘meaning’: what is meaning, how does it arise, how is it learnt, and how is it computed and practised? Until recently, the study of these questions has been separated by old, traditional, disciplinary boundaries, each studying different aspects of these questions — almost as if there are various notions of meaning around (a logical one, a linguistic one, a psychological one, a practical one etc.). Nowadays, however, one can see a growing convergence of efforts, both for discipline intrinsic reasons, as well as for interdisciplinary interests.

In the theoretical disciplines the focus of interest is moving from the abstract modeling of meaning towards the model-

### Objective

The proposal aims to combine strong research traditions on the use of language in theoretical linguistics, cognitive psychology and artificial intelligence.

The project will be carried out at the Department of Philosophy of the University of Amsterdam in the Institute of Logic, Language and Computation (ILLC).

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ing of actual interpretation and use, witness the emergence of dynamic semantics, and the game-theoretical approach to pragmatics. The latter approach expands on the insight that the intended interpretation of natural language expressions is underspecified by their conventional meaning, and that the extra step from conventional/semantic meaning to actual interpretation requires additional reasoning, taking into account additional contextual features.

It is not clear, however, which part of a communicated content depends on conventional meaning and which part evolves from practical reasoning. Standard game and decision theory — and traditional pragmatics along with it — is based on strong rationality assumptions, which are sometimes too strong to be reasonable. Even though it is well-

### Applicants

- Dr. Paul Dekker (Vernieuwingsimpuls for the project ‘Formal Language Games’).
- Dr. Robert van Rooy (KNAW fellow on the project ‘Games, Relevance, and Meaning’).
- Prof. dr. Frank Veltman (Logic and Cognitive Science).

### Partners

- Prof. Herbert H. Clark (Cognitive Psychology, Stanford).
- Prof. dr. Luc Steels (Artificial Intelligence, Brussels),

known that the human brain performs an incredible amount of processing in interpreting natural language, assuming that it takes into account all the potentially relevant costs, benefits, preferences, likelihoods and common knowledge involved seems unlikely. Thus, the pressing question is as to how far the interpretation and production of natural language expressions is conventionalized. The task is that of finding a balance between ‘institutionalised’ convention on the one hand and ‘on the spot’ reasoning on the other, a balance which is reasonable from both a cognitive and social point of view.

Formal and abstract notions of meaning developed in theoretical linguistics have been seen to be too rigid to account for the flexibility of language users. Herbert Clark has emphatically and convincingly argued that the use of language is both of a cognitive and a social nature, and that these two are constitutive aspects of the actual and intended interpretation of concrete utterances. The study of language should therefore pay due account to both aspects. The aim then is to lay bare the cognitive, intentional and contextual conditions which make actual communication possible at all, and, thus, to delineate preconditions for the emergence of meaning in practical situations.

The role of conventions, and conventional meaning in particular have been studied, mainly within *standard* game theory with all its strong assumptions of rationality. Recent work in *evolutionary* game theory shows that social conventions can evolve without making too strong rationality assumptions. This theoretical framework seems to be appropriate to account for the evolution, acquisition, and change of conventional meanings as well. Moreover, the ongoing ‘Talking Heads’ experiment by Luc Steels and his group in artificial intelligence has shown how coordinated communication can emerge from the interaction of individual cognitive robotic

agents, thus proving the viability of the idea that meaning is not essentially innate, nor learned through stepwise induction from examples and counterexamples, but gradually constructed and practised as part of situated language games.

#### Main Research Questions

- » Presently, the evolution of language is studied both from the (theoretical) perspective of evolutionary game theory, and the experimental one in artificial intelligence (Steels). What can the two perspectives learn from each other?
- » Reasoning and convention both play a role in the emergence and use of natural language. What are the proper balances between the two, theoretically, and experimentally speaking? Why are certain conversational protocols more likely to emerge than others?
- » In contrast to animal languages, human language can combine elementary signals into compound messages with a recursive meaning. An important question is how far the theoretical and artificial models of language evolution can be pushed in order to account for uses of language other than the exchange of purely factual, referential information? (Think of questions, imperatives, negation, modalities, reflexive information about information itself.)

We aim to bring these developments together. We want to combine the forces of the fully general theoretical research pursued by our group at the ILLC in Amsterdam, with that of the empirical and experimental work pursued in Stanford and Brussels so as to get a theoretical grip on the emergence of meaning, in general, and in specific occasions of use.