



LIKE A KID IN AN INTELLECTUAL
CANDY STORE
LUC STEELS

Luc Steels is a Professor of Computer Science at the University of Brussels and Director of the Sony Computer Science Laboratory in Paris. He studied Linguistics at the University of Antwerp followed by Computer Science and Artificial Intelligence at M.I.T. Steels published a dozen books in his field as well as hundreds of papers on various topics related to Artificial Intelligence, ranging from knowledge representation and expert systems to robotics, machine learning, and natural language processing. About 30 Ph.D. theses have graduated under his supervision. He was elected a member of the Flemish Academy of Belgium and the Academia Europea, and has played an active role in various academic societies, including the European AI society (ECCAI). Steels has also been active in the interactions between art and science together with artist Olafur Eliasson and theater director Jean-François Peyret. – Address: AI Laboratorium – IOG720, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium. E-mail: steels@arti.vub.ac.be

Joachim Nettelbeck and his staff at the Wissenschaftskolleg have a secret recipe. They figure that if you make scientists happy, allow them to focus entirely on the subject they feel absolutely passionate about and bring them together within a community of like-minded peers, they become highly productive and possibly achieve something that even they themselves did not imagine to be possible. I have witnessed and experienced that this recipe works. The conditions at the Wissenschaftskolleg are indeed extraordinary. Every staff member, from the welcoming reception (the “Empfang”) to the computing services, from the library to the kitchen, from the language courses to the fellow services, everybody reaches such a high level of excellence and puts such dedication and care into their

work that you feel like a prince. It seems impossible to express my gratitude in return for so much generosity.

I personally came to the Wissenschaftskolleg with a project to finally write the book that I had been thinking about for many, many years. I have been working on a theory of the origins and evolution of language for about a decade now, and it seemed the right time to bring the ideas and experiments together in a book, particularly because 150 years ago Darwin published his magnificent volume *On the Origin of Species*, and throughout the year evolutionary biologists were celebrating this founding event in their field.

The theory I am trying to develop is not so much about when and where human languages originated, something we can probably never know, but about the social and cognitive prerequisites required for language and the cultural evolutionary dynamics that unfold when humans apply their cognitive capacities to the task of building and acquiring a shared symbol system. To develop and test my theory, I set up computer simulations and even robotic experiments in which we program a group of “artificial language agents” to play language games.

We simulate all the cognitive functions that are needed for language, including perception of the world, conceptualization of what to say, lexical and grammatical production, speech articulation and recognition, parsing of utterances, interpretation of meaning, enactment of the consequences of interpretation and, most importantly, processes for acquiring all the necessary know-how and for inventing and adapting the conceptual frameworks and linguistic conventions needed for language and for aligning and coordinating language across the members of a population. We then put the agents in a kind of micro-world and endow them with scripts to play a language game. Then we set the whole thing in motion and examine whether they are indeed able to self-organize a communication system from scratch. If that is the case, we know that the cognitive functions and interactions patterns we supplied in the beginning of the experiment are necessary and sufficient to see a symbolic communication system emerge.

From day one I worked extremely hard on my book project, sitting alone in my office and writing pages and pages of text, but then throwing them away, almost as fast as I could write them. I struggled, became frustrated, and as the days shortened and the grey clouds hovering over Berlin no longer seemed to give way to sunshine, I became more and more doubtful of my project and whether I had enough talent to achieve it. Clearly my theory was not yet “ripe enough” to be written out in a systematic way. At the end of the year I had piles of text, some sections I found already satisfactory, but most of the others

need a lot more work. But that does not mean that I went home with the feeling that my project failed. On the contrary, I believe I was able to develop a new perspective on the research I had been doing with my team over the past decade and now see much more clearly what we have to do in the coming decade. I now see how the story can be told, not only to linguists but also to scientists in other fields who have an interest in this subject matter. Although at home I will be swamped again by my work as a teacher and lab director, I have now found a new strength and unity in my work so that I hope to continue the momentum of the writing process. Apart from steady work in my office, there are two elements that played a very important role in reaching this breakthrough in my thinking.

The Tuesday colloquia are extraordinary events. Fellows work hard to show the best of themselves and to make their research topics and methods accessible to the Wissenschaftskolleg community. Already in the first weeks, we had some extraordinary talks by evolutionary biologist colleagues: James Mallet, Axel Meyer, Patrik Nosil and Jeff Feder. Their talks were to me extremely insightful, not only because they showed that speciation is an ongoing process, but also because of the kind of methodology they use to study biological evolution. Darwinian evolutionary theory is not like Newtonian mechanics, where you just plug in parameters and measurements and you get predictions about the movement of any physical object anywhere in the cosmos. It is more a framework, and if you want evolutionary explanations for specific features, such as the colour on the wings of butterflies, the presence of eggspots on the backfin of fish or the shapes and colours of stick insects, you have to instantiate the framework and find out what the ecological role is of the phenotypical feature you are interested in, how it is established through genetic and developmental processes, what kind of genomic changes might have taken place and what selective advantage the trait has within the ecological conditions in which the species has to survive and reproduce.

From the presentations of these evolutionary biologists at the Wissenschaftskolleg, their papers and further discussions I have had with them, I realized that a theory of the origins of language had to have an epistemological status similar to that of biological evolutionary theory. That means that it can only be a framework, a basic selectionist logic, that then needs to be filled in order to develop evolutionary explanations for specific cases. There is not going to be a single set of master equations that explains how language evolved; there will never be a unique usage that triggered the origins of language or a unique cognitive capacity that explains it all. But we might be able to understand the gen-

eral overarching principles that drive a population with enough cognitive capacities and the right ecological challenges and social structures to develop a symbolic communication system of the complexity of human languages. And we might then be able to apply these principles to develop evolutionary explanations for the key features found in human languages.

I realized next that the selectionist logic at the core of Darwinian evolutionary theory could not be applied directly, meaning at the level of genetic evolution and natural selection, as had been proposed earlier by several linguists and psychologists, most notably Steven Pinker and Ray Jackendoff. Instead, this logic had to be transposed to the linguistic and cultural level. The features we want to explain are features of human languages, like the use of a tense and aspect system for talking about the temporal structure and characteristics of events, the use of case markings to express the role of participants in events, a system of basic colour terms to express hue and brightness distinctions etc. We need to understand the role of such a language system in symbolic communication, how it is learned, how it is built up and expanded and how concrete language systems (e. g. the case grammar of Latin or the aspect system of Russian) emerge and become coordinated in a population. We also need to understand how the language strategies underlying these language systems could emerge by the configuration of cognitive functions that are also useful in other domains, like spatial navigation, and what kind of selective advantage they give to language users for reaching higher communicative success, greater expressive power and minimal cognitive effort.

I elaborated this mapping between biological selectionist theory and linguistic selectionist theory for the first time during my Tuesday Colloquium in May and then wrote it up in a large paper that will appear as a programmatic statement in the first issue of the *Journal of Evolutionary Linguistics* that I have meanwhile set up with some colleagues. Already several case studies have been treated within this framework of “Language Evolution by Linguistic Selection”, particularly for the domain of basic colour terms, which has been intensely studied by anthropologists, psychologists and linguists. Many more case studies will have to be developed before more people are convinced of the framework as a whole and accept it as an adequate explanation, but that is exactly what I intend to do with my students over the coming years.

There was a second important force helping to focus my thinking and ideas. These were the weekly discussions with our group on “Understanding the Brain”, brought together by biologist and cybernetician Holk Cruse and including philosopher Thomas

Metzinger, computer scientist and neuroscientist Srinivas Narayanan and, much later in the year, cognitive psychologist Rafael Núñez and neuroscientist Lisa Aziz-Zadeh. Often other Fellows at the Wissenschaftskolleg joined our discussions and thus brought additional perspectives and ideas.

The objectives of the brain group are at first sight very different from my project on language evolution, but that is not the case. Language exercises the whole human brain to the fullest. It requires such extraordinary capacities that only our own species is able to master language. A lot of the debates about the origins of language centre on the question whether the human brain is uniquely structured or has unique modules for language that are strongly genetically determined, so that the logic of natural selection could apply. I personally believe that language is a consequence of recruiting many cognitive functions that are useful for a broad range of tasks. The functions include a bi-directional associative memory, perspective taking and perspective reversal, rich categorizations, priming, heuristic search and so on. What we need to understand, therefore, is how the recruitment and flexible configuration of these functions can take place and how task demands can drive this process. The question how this is really achieved by the brain is almost entirely open. Holk Cruse and Srinivas Narayanan presented progressively more powerful brain architectures in our weekly seminars that show how some of the cognitive functions needed for language can be achieved by neural networks that more realistically fit human neurobiology than do the computational implementations that I use in my own experiments. Moreover, during the workshop that we organized with the group, Friedemann Pulvermüller and Lisa Aziz-Zadeh presented tantalizing data showing clearly that brain areas outside the traditional language areas (Broca's and Wernicke's) become active to deal with the semantics of human language. But much more work needs to be done.

In our brain group we had enormously lively conversations. Each of us came from very different backgrounds to an interest in the brain, and therefore a significant but very important activity was simply to coordinate our vocabularies, figure out which questions each of us found important and exchange technical ideas. All this certainly impacted my thinking on language evolution, although I have the feeling that the puzzles that came up are so far from being solved that I will have a hard time thinking them through at this point.

I look back on a most enjoyable and most productive year. This is not only due to the extraordinary conditions at the Wissenschaftskolleg, but also to the many brilliant colleagues with whom I was able to share ideas and happy times. I must also mention Berlin.

While living in this city, I fell totally in love with it. The cultural and scientific resources of Berlin are absolutely amazing. The quality of life in terms of (relative) lack of pollution and the friendliness of the population makes it in my eyes the most livable and exciting city in Europe today. One of my highlights this year was undoubtedly singing Bach's Mattheus Passion with my choir, which rehearsed in the John-Lennon-Gymnasium in Mitte and performed in the Emmauskirche in Prenzlauer Berg. But there were also my frequent bicycle trips through the city, the cafés near Savignyplatz or in Neukölln, the festive seventies atmosphere at the Mauerpark, the many operas and theatre pieces I was able to see, the art galleries and much more. I hope Berliners do not get sucked up in a kind of megalomania that has made London, Paris, Brussels and other European capitals so stressful and unlivable. I hope they keep the river banks of the Spree open to all, keep spaces for "Kleingärtner" inside their neighbourhoods, keep their efficient Tegel airport, keep using bicycles instead of motorcycles, keep spaces for children to play and keep their curiosity and time for conversation, art and culture.