

SUMMARY OF DISSERTATION

COMPLEX SIGNALS: REFLEXIVITY, HIERARCHICAL STRUCTURE, AND MODULAR COMPOSITION

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Communication is found everywhere in nature, but language is unique to humans. Thus, the question arises:

How did language evolve?

That is, how did language (the linguistic capacities of humans) emerge or evolve from non-language—i.e., the communications systems that are universal in nature, from apes and monkeys to bees and bacteria. My dissertation suggests answers to these and related questions by providing a novel way of understanding the evolution of complex communicative dispositions. I show how simple communication systems themselves might compose to create more complex systems. The framework that I present prioritises the *reflexivity* of language as the correct explanatory target for bridging the gap between ubiquitous animal communication and distinctively human language.

This work challenges the dominant view in language-origins research, which tries to resolve this explanatory gap by demonstrating how possibly *compositional* (or *hierarchical*) *syntax* evolved. *Generative capacity* is a key difference between communication and language that researchers often point to. A principle of generative capacity explains how arbitrary sounds can be combined in unlimited variation to form semantically meaningful and syntactically permissible units—e.g., sounds combine to form words, and words combine to form sentences and phrasal expressions. This is captured by the *Principle of Compositionality*, that the meaning of a complex expression is a function of the meanings of its parts and how they combine. Thus, with a limited vocabulary and a finite set of grammatical rules, human language allows for the production of an unlimited number of novel expressions. Simple communication systems that arise in nature lack this unbounded character.

However, I argue that there is scant empirical data to support the emphasis researchers place on compositional syntax. No animal communication system thus studied appears to readily combine signals in systematic ways to create new meanings. Combinatorial systems that do exist in nature either combine signals in minimal ways, or they evolved independently of human communication systems and cannot be understood as precursors of language. Thus, it is a mistake to assume that, because compositionality is a salient property of language which is absent in

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simple communication systems, research on language origins must centre on the evolution of generative capacity itself.

As an alternative, I suggest that the *reflexivity* of language—namely, the ability to use language to talk *about* language—provides an apt explanatory target for such an evolutionary account. On the one hand, reflexivity is also absent in animal communication systems and so provides a viable alternative to compositional syntax. On the other hand, unlike compositional syntax, I show that reflexivity has salient precursors in simple communication systems. As a result, a gradualist perspective which prioritises reflexivity can account for empirical data. Finally, I demonstrate how reflexivity can give rise to hierarchical structures so that compositional syntax arises as a *byproduct* of reflexive communication on my account.

The first part of my dissertation provides the philosophical foundation of this novel account using the theoretical framework of Lewis-Skyrms signalling games. These chapters further draw upon and connect relevant work in evolutionary biology, linguistics, cognitive systems, and machine learning. Chapter 1 introduces the signalling-game framework and contextualises it with respect to traditional philosophy of language.

Chapter 2 presents empirical data from biology and linguistics to argue two things. First, there is scant empirical evidence for any precursor to compositional syntax in nature. Second, there is no gradualist explanation of compositionality, insofar as it is an all-or-nothing property of language. A consequence of this analysis is that, contrary to the standard account, compositional syntax is not even the correct target of an evolutionary explanation.

Chapter 3 then argues that the correct target is the *reflexivity* of language, showing how reflexivity aids the evolution of complex communication via a process of modular composition. This chapter connects parallel research in the evolution of language and cognitive systems and highlights plausible empirical precursors seen animals. When such complexity arises at a small scale, it may lead to a ‘feedback loop’ between communication and cognition giving rise to the complexity we see in natural language.

The second part of my dissertation (Chapters 4-6) provides a set of models, along with analytic and simulation results, that demonstrate precisely how and under what circumstances this process of modular composition is supposed to work.

I emphasise that communication is a unique evolutionary system in the following sense. Once a group of individuals has learned some simple communication convention, those learned conventions may be used to influence future communicative behaviour. When faced with a novel context, an individual can learn a brand new disposition from scratch; however, the individual may also learn to take advantage of previously evolved dispositions. Indeed, individuals may learn to take advantage of pre-evolved *communicative* dispositions to thereby influence the evolution of future communication; this is the conception of reflexivity, as an evolutionary mechanism, which I examine.