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## EVOLUTIONARY PATHS TO COMPOSITIONAL LANGUAGE

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We present results from simulations studying the hypothesis that mechanisms for landmark-based navigation could have served as preadaptations for compositional language. It is argued that sharing directions would significantly have helped bridge the gap between general and language-specific cognitive faculties. The experiments in this study are built around two observations: firstly, that it is possible to formulate a range of landmark-based navigational behaviours of increasing complexity, and a corresponding range of communicative behaviours, where each pair of behaviours requires the same type of abstract computation to be carried out. Secondly, that the necessary step from possessing each navigational behaviour to using the corresponding communicative behaviour for the purposes of sharing directions is relatively simple, and the same in all cases, namely, to be able to name a landmark, and be understood (Kazakov & Bartlett, 2002). We have previously shown that environmental factors, such as the amount of food present and the speed with which it perishes, can have a great impact on the relative benefits of communication, as shown on a representative range of environments (Bartlett & Kazakov, 2005).

Here a number of different levels of navigational and communicative abilities are considered, resulting in a range of possible evolutionary paths. The selective pressures for, resp. against, increased complexity in either faculty are then evaluated for selected environments. *The study aims specifically to identify whether there is a viable evolutionary path leading to compositional language, and if so, under what circumstances.*

The results show that environmental conditions can render a step towards more complex communication either desirable or harmful. For instance, in environments with volatile resources, there is a considerable benefit for individuals with an al-

ready complex navigation if they adopted a simple (proto)language allowing them to share a path towards a resource as a sequence of landmarks. At the same time, sharing directions in a way that leaves both speaker and hearer with very similar chances of exploiting the same resource appears harmful. The full set of results suggest that *very specific initial conditions and sequence of changes in the environment, resp. the ecological niche occupied, would have been needed to select for compositional language. Subject to these conditions however, there would be a significant evolutionary pressure in favour of a (proto)language using order, but no hierarchical structure.*

In comparison with other theories about the origins of language, which either hypothesise the existence of protolanguage with multiple-word utterances without word order (Bickerton, 1990), or the emergence of fully syntactic language without any intermediate stages (Hauser, Chomsky, & Fitch, 2002), these results introduce a middle ground between theories from the two ends of the spectrum. A rudimentary form of communication different from all other animal communication systems, could have emerged and been selected for much earlier than language with phrase structure. The main breakthrough required for such (proto)language would be the ability to learn and use a shared, possibly very limited, vocabulary of referential signals. While this ability may have evolved from animal signals, such as food calls, the mechanisms for syntax could have come about as a preadaptation, rather than the result of evolutionary pressure for language alone. Such a model would make it easier to explain the sudden emergence of ‘modern’ language through the addition of phrase structure (e.g. operator ‘Merge’ (Chomsky, 1995)) to an already existing combination of a lexicon and a simpler, regular language parser, which only handled order. This represents a middle ground, which brings closer hypotheses about syntax that have so far appeared difficult to reconcile.

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