

## Emergent Compositionality in Language Evolution through Negotiation

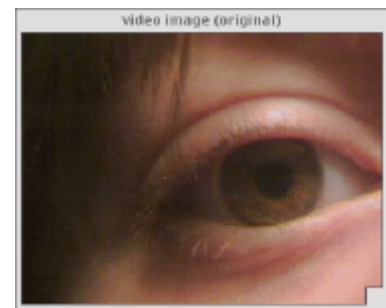
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Compositionality is seen as one of the major properties of natural languages that any theory of language origins needs to explain. So far there have been quite a few computational experiments showing that compositionality emerges to handle the learning bottleneck. These experiments are usually framed in terms of the iterated learning model (Kirby & Hurford, 2001) where an agent is given a corpus and extracts a grammar which it then uses to produce a corpus for an agent of the next generation. In this paper we show that compositionality can also emerge in Language Game Models which rely on negotiation in peer-to-peer interactions and horizontal transmission (Steels, 2001). We also show that the choice for compositionality is based on properties of the environments. If there is regularity in the environment then there is an increased chance for compositional rules to dominate.

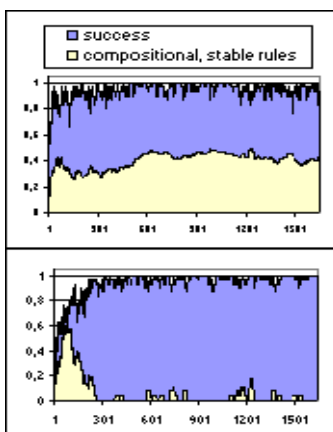
The experiment is similar to the Talking Heads experiment. The agents play a "Naming Game": They have to agree on a way to name an input they both see. The speaker may use one of its rules to map the input onto a word or create a new one. The hearer may understand this by a rule it already knows or induce a new one. If rules are used, their confidence scores are increased; competing rules that were not chosen are decreased. As the chance that a rule be used depends on its confidence score, this implements positive feedback and lateral inhibition mechanisms, driving a self-organisation process towards global coherence.

Inputs are three-dimensional vectors. Environments are probabilistic sets of input vectors. There are two kinds of environments: In the structured one, input vectors correspond to colours in digitized images, resulting in an extremely uneven distribution. In the unstructured one, vectors are created randomly with an even distribution.

Compositionality comes into play as the agents may switch from rules expressing whole vectors to rules expressing only particular, reoccurring components.



*Pictures used as structured input.*



*Games in structured (top) and unstructured (bottom) environments.*

In the experiment, we see that the population reaches a shared lexicon with high communicative success in both environments. Compositional rules, however, only stabilize in a structured environment. The stable compositional rules describe main axes among which input vectors vary - in the absence of such axes, no clear favourite can emerge and the holistic rules remain dominant.

While in the ILM, grammar is viewed as a system for the compact coding of meaning into form, in LGA, grammar is above all a way to optimise communication. In this context, finding that compositionality may arise without vertical transmission is not just a matter of style or focus, but supports profoundly different assumptions about how the origins of grammar can or should be approached.

Kirby, S. and J. Hurford (2001) The Emergence of Linguistic Structure: An Overview of the Iterated Learning Model. In: Cangelosi & Parisi (eds.) *Simulating the Evolution of Language*, Springer-Verlag, Berlin

Steels, L. (2001) Language Games for Autonomous Robots. In: Shadbolt, N. (ed.) *IEEE Intelligent Systems*, vol. 16, Nr. 5, pp. 16-22, New York: IEEE Press.