Evolution and emergence of sign production and interpretation

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Extended Abstract

Computational modeling of the emergence of semiotic processes, such as language and communication, has been consolidating as an important methodology (Wagner et al., 2003; Noble et al., 2010). As the main form of interaction between agents in these experiments, communication has been a significant research subject. Primarily, it depends on the production of representations (by an utterer) and the interpretation of them (by an interpreter). Despite the fact that representation processes are in the foundations of communication, little discussion about such processes can be found, such as, the emergence of fundamental types of representations and their referential relations.

We have previously simulated the emergence of interpretation of two different types of representations (symbols and indexes) in communicative interactions (Loula et al., 2010), and studied further the cognitive conditions to such processes (Loula et al, 2011). Here we propose to evaluate representation processes in the emergence of both interpretation and production of multiple representations, with multiple referents. To do so, we apply a neural network model as the cognitive architecture for creatures, which can become utterers and interpreters. The experiment applies C.S.Peirce's pragmatic theory of signs as theoretical basis.

To test the conditions for the emergence of semiotic processes, artificial creatures are evolved to collect resources in a virtual environment. Two types of resources can be found in the environment, with positive and negative values, and creatures can vocalize two types of signs. Creatures are controlled by a feed-forward neural network with three layers. For better analysis of neural network activation patterns, we applied a winner-takes-all (WTA) mechanism to the middle layer and output layer. Auditory middle layer can connected to the output layer (type 1), probably defining an indexical sign interpretation, or can be connected to the visual middle layer, defining an associative memory between auditory activations and visual activations (type 2), and defining a symbolic sign interpretation. Evolution allows the creatures to adapt to the task of collecting positive resources and avoiding negative resources.

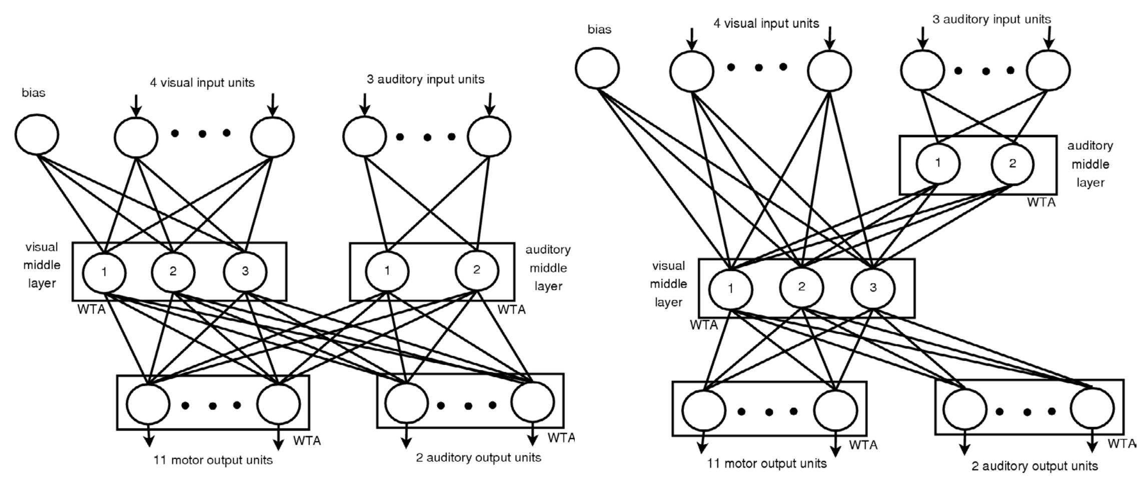

Figure 1: Neural networks used by creatures. Left: Type 1 architecture. Right: Type 2 architecture.

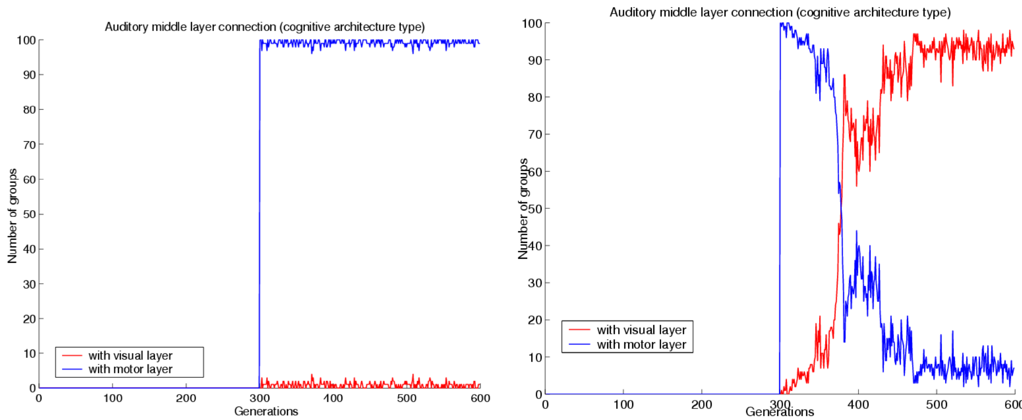

Figure 2: Evaluation of auditory middle layer connection for the first simulation (left) and for second simulation (right).

We ran two simulations of the experiment. In the first one, only the neuron with the highest positive activation has output of 1.0 (the others became null), and in the second simulation, the activation value of this neuron must 1.0 higher than the second highest active neuron, therefore it is harder to learn motor coordination in this second configuration. In the first simulation, motor actions could be easily coordinated with sensorial input, and the adaptive behavior evolved was a direct response to the communicated signs, an indexical interpretation (figure 2). Increasing the cost of cognitive traits acquisition in the second simulation, symbolic interpretation of signs was the adaptive response (figure 2). The proposed neural network allowed a detailed inner observation of cognitive processes during experiments and therefore to analyze the semiotic relations being established in the utterer and in the interpreter.

References

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