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Chapter XI

Synthetic Approach to Semiotic Artificial Creatures

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ABSTRACT

Here we propose, based on the Peircean semiotics and informed by neuroethological constraints, a methodology to simulate the emergence of symbolic *predator-warning communication among artificial creatures in a virtual world of predatory events. In order to build a digital scenario, and infer the minimum organizational constraints for the design of our creatures, we examined the well-studied case of semiosis in East African vervet monkeys* (Chlorocebus aethiops) *and its possible neuroanatomical substrates.*

INTRODUCTION

Synthetic methodologies have been used to model and simulate cognitive processes from many different perspectives. Computational neuroethology (Cliff, 1995), evolutionary robotics (Kaplan, 2000; Nolfi & Floreano, 2002; Steels & Vogt, 1997),

artificial life (Langton, 1995), animat research (Dean, 1998), and synthetic ethology (MacLennan, 2001, 2002) are some of the interdisciplinary areas of research dedicated to the synthetic design of intelligent systems and creatures. These areas depend heavily on a biological foundation from where they take constraints and ideas for the design of adaptive artificial creatures.

Different levels of the organization of semiotic processes can be studied by way of modeling and simulation (Cangelosi & Turner, 2002; Parisi & Cangelosi, 2002; Perfors, 2002). These levels include the simulation of syntactic structures (Batali, 1994, 1998; Kirby, 1999), morpho-syntactic compositionality (Ellefson & Christiansen, 2000), lexicalization phenomena (Cangelosi & Parisi 1998; Hurford, 1991; Steels, 1999; Steels, Kaplan, McIntyre & Van Looveren, 2002), symbolic competence (Cangelosi, 2001), communication (Hutchins & Hazelhurst, 1995; Kvasnicka & Pospichal, 1999; Steels, 1997; Steels & Kaplan, 1999) and meaning creation in communication (MacLennan, 2001; Smith, in press).

The experiments using situated agents, virtually or physically embodied artificial creatures able to interact with an environment, allow a focus on the emergence of semiotic processes associated with several cognitive tasks. Depending on the framework, the strategies allow the testing of various factors affecting the phylogeny and ontogeny of semiotic processes, such as the differences between innate and learned sign systems, the adaptive role of compositional languages, the adaptive advantage of symbolic processes, the hypothetic minimal neural substrate of these processes, the mutual influences between different semiotic competences and low-level cognitive tasks (attention, perceptual categorization, motor skill), and the hierarchical presupposition of fundamental kinds of semiotic competences (iconic, indexical, symbolic) operating on *symbol grounding* processes, the main topic of this work.

We propose, based on the Peircean semiotics and informed by neuroethological constraints, a methodology to simulate the emergence of *symbolic* predator-warning communication among artificial creatures in a virtual world of predatory events. In order to build a digital ecosystem, and infer the minimum organizational constraints for the design of our creatures, we examined the well-studied case of semiosis in East African vervet monkeys *(Chlorocebus aethiops)* and their possible neuroanatomical substrates. There are obvious connections of this work with ALife, synthetic ethology, and correspondence with *creatures* (Cliff & Grand 1999), and with the experiments on *symbol grounding* and emergence of symbolic competence in simple virtual worlds (Cangelosi, 2001; Cangelosi et al., 2002; Cangelosi & Turner, 2002; MacLennan, 2001). The computational techniques we apply do not represent a new venture in terms of engineering development and have been studied for decades. However, the way in which techniques and theoretical framework are integrated here is original. As a core contribution, we propose using Peircean semiotics (see the second section) to investigate the logical and biological mechanisms underlying minimal conditions for symbolic emergence.

The simulation in artificial systems of mechanisms capable of generating symbolic processes is a key problem in AI and ALife (Brooks, 1990; Harnard, 1990; Vogt, 2002, 2003; Ziemke, 1999; Ziemke & Sharkey, 2001). A particularly important question is how higher level semiotic processes (e.g., symbolic) emerge from lower level processes (e.g., iconic)? It has been suggested that biologically inspired computational modeling techniques