2011-12

Embodied compositionality

Cangelosi, A

Comment

Embodied compositionality
Comment on "Modeling the cultural evolution of language" by Luc Steels

Angelo Cangelosi

University of Plymouth, Drake Circus, Plymouth, United Kingdom

Luc Steels [10] provides a comprehensive overview of the key theoretical issues on the cultural evolution of language and of the contribution of computational and robotics models to the study of the social emergence of language in societies of interactive agents. In this short commentary, I would like to extend the discussion by focusing: (i) on the origins of the hierarchical structure of language, as grounded in the embodied compositional nature of motor representations and skills such as those of object manipulation; and (ii) on the interaction of genetic and cultural evolution processes in language evolution.

For the issue of compositionality and hierarchical structure in language, Steels [10] acknowledges that "Semantics-directed approaches hypothesise that the main source of hierarchical structure in language comes from the fact that semantics is compositional". I would like to further strengthen and extend this argument by highlighting the fact that the compositional nature of semantics derives from the compositional nature of embodied representations and manipulation capabilities of bipedal humans. An evident example of this is the compositional and hierarchical nature of object manipulation capabilities, and the underlying, parallel interaction between action and language learning during development [3]. Object manipulation skills, such as those involved in tool use and tool making, clearly rely on the systematic, hierarchical re-use and repetition of motor primitives. This link between manipulation skills and language learning (and evolution) has been proposed by language origins theorists such as Corballis [6] and neuroscientists [9]. Moreover, this has been investigated in multi-agent computational models of action/language evolution (e.g. [2,4]). Future embodied models of action/language interaction, especially those based on cognitive robotics experiments of object manipulation, can shed light on the detailed mechanisms leading to the evolution of compositional motor representations, compositional semantics and thus compositional, hierarchical language systems.

A second research issue that I would like to add to Steels's comprehensive review of the models of the cultural evolution of language is the importance of the interaction between genetic and cultural evolutionary processes in

language origins. The most evident example of such a type of phenomena is the Baldwin effect [1,11]. The Baldwin effect consists in the fact that what a species must initially learn during each member's lifetime can, over time, become part of the genetic makeup of that species (genetic assimilation). The Baldwin effect has been explicitly used as an argument for the explanation of the origins of language. This has contributed to the debate whether the Baldwin effect can explain the evolution of a Language Acquisition Device, as in Pinker and Bloom's [8] hypothesis, or if Baldwinian mechanisms can be invoked for the genetic assimilation of general, non-linguistic cognitive capabilities, which then also supported language use. Computational models of the Baldwin effects in language evolution have contributed to this debate [5,7,12]. For example, Munroe and Cangelosi [7] modelled the combination of genetic evolution and cultural learning mechanisms for the emergence of a communication system in a population of agents. In this model, Baldwinian processes explain the assimilation of a predisposition to learn quickly and efficiently the language the agents are exposed to, rather than the assimilation of any structural properties associated with a specific language.

To conclude, a stronger focus on the computational modelling of the embodied nature of object manipulation capabilities, and on the interaction dynamics of genetic evolution and cultural evolution, in addition to new research on the other key issues discussed by Steels [10], can significantly enhance our understanding of the complex interaction of genetic, cognitive and cultural phenomena in the evolution of language.

References

[1] Baldwin JM. A new factor in evolution. The American Naturalist 1896;30.

[2] Cangelosi A. Grounding language in action and perception: from cognitive agents to humanoid robots. Physics of Life Reviews 2010;7(2):139–51.

[3] Cangelosi A, Metta G, Sagerer G, Nolfi S, Nehaniv CL, Fischer K, et al. Integration of action and language knowledge: a road map for developmental robotics. IEEE Transactions on Autonomous Mental Development 2010;2(3):167–95.

[4] Cangelosi A, Parisi D. The processing of verbs and nouns in neural networks: insights from synthetic brain imaging. Brain and Language 2004;89(2):401–8.

[5] Christiansen M, Reali F, Chater N. The Baldwin effect works for functional but not arbitrary features of language. In: Cangelosi A, Smith ADM, Smith K, editors. The evolution of language. Toh Tuck Link Singapore: Word Scientific Publishing Co; 2006. p. 27–34.

[6] Corballis MC. From hand to mouth: the origins of language. Princeton, NJ: Princeton University Press; 2002.

[7] Munroe S, Cangelosi A. Learning and the evolution of language: the role of cultural variation and learning cost in the Baldwin effect. Artificial Life 2002;8:311–39.

[8] Pinker S, Bloom P. Natural language and natural selection. Behavioral and Brain Sciences 1990;13:707–84.

[9] Rizzolatti, Arbib M. Language within our grasp. Trends Neuroscience 1998;21:188–94.

[10] Steels L. Modeling the cultural evolution of language. Physics of Life Reviews 2011;8(4):339–56 [in this issue].

[11] Turney P, Whitley D, Anderson RW. Evolution, learning, and instinct: 100 years of the Baldwin effect. Evolutionary Computation 1996;4(3):iv–viii.

[12] Yamauchi Y. Can the Baldwin effect really explain the evolution of the LAD? In: Desalles JL, Ghadakpour L, editors. Proceedings of the 3rd international conference on the evolution of language. Paris: ENST; 2000. p. 263–5.