2. The Evolution of Language

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On constructing a research model for historical cognitive linguistics (HCL): Some theoretical considerations

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Abstract

This paper examines how historical cognitive linguistics can benefit methodologically through the application of the notion of language as a complex adaptive system. The idea that languages are complex adaptive systems (CAS) was introduced initially in computational evolutionary linguistics, a discipline that was and remains inspired by biological, systems theoretical approaches to the evolution of life. Here the way that the CAS approach serves to replace older historical linguistic notions of languages as organisms and languages as species is explained as well as how the CAS approach can be generalized to encompass linguistic domains. Specifically, an overview of the CAS approach and its implementation in linguistics is provided with an emphasis on stigmergic, embodied, usage-based and socio-culturally situated language studies in particular.

> Scientific revolutions are, in fact, metaphoric revolutions, and theoretical models should be seen as metaphoric redescriptions of the domain of phenomena. (Arbid and Hesse 1986: 156)
>
> Languages meander like great rivers leaving oxbow traces over forgotten beds, to be seen only from the air or by scholars. Language is like some infinitely inter-fertile family of species spreading or mysteriously declining over time, shamelessly and endlessly hybridizing, changing its own rules as it goes. Words are used as signs, as stand-ins, arbitrary and temporary, even as language reflects (and informs) the shifting values of the peoples whose minds it inhabits and glides through. We have faith in 'meaning' like we might believe in wolverines – putting trust in the occasional reports of others, or on the authority of once seeing a pelt. But it is sometimes worth tracking this trickster back. (Snyder 1992: 24–25)

1. Introduction

Our paper begins by focusing on theoretical issues relating to 19th and 20th century conceptual cross-fertilization between linguistics and evolutionary bi-

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ology, namely, the way that aspects of research models utilized by the natural sciences, most particularly biology, have intersected with theories of language evolution, and hence, the manner in which the traditional research paradigm of historical linguistics was constructed in terms of the way that "language" was conceptualized (Bugarski 1999; Frank 2008b; Janda and Joseph 2003). Most particularly, we examine the three points of intersection. First, we will look at the analogy of "language" as an "organism"; second, we will explore the way that "language" came to be viewed simultaneously as an "organism" and "species"; and third, we will conclude by taking up the most recent position that views "language" as a "complex adaptive system". Initially, we provide a brief review of the way these disciplinary interactions have shaped how we think about "language" and by implication the role played by these conceptualizations of the phenomenon of "language" in historical linguistics, including the heuristic applications of evolutionary biological thinking to linguistics, and to the nature of variation and language change (Croft 2000, 2002; Mufwene 2001, 2005). Finally, in this first section we introduce the "complex adaptive system" (CAS) approach (cf. Lansing 2003), a framework currently gaining ground in the theoretical discourse of genomics as well as many other fields.

In the next section of the paper we turn our attention to the question of how those of us interested in constructing a research model for historical cognitive linguistics (henceforth HCL) might profit from recognizing the remarkable conceptual connections holding between these allied disciplines and our own concerns with language change. By gaining a better understanding of the way that metaphors/analogies have flowed back and forth, heuristically, across disciplinary boundaries, specifically between biology and linguistics, we will be able to appreciate better how the phenomena under analysis in each field have undergone modification over time, e. g., how "language" first was analogized to an "organism", later on compared to a "species" (Gontier 2006a, b, 2008) and how it has come to be viewed as "activity-process" (Frank 2008b).

Finally we address the contributions that HCL might make to research currently being carried out in related disciplines concerned with the evolution of language and culture, if HCL were to frame its findings in more cross-disciplinarily recognized terminology and adopt the more inter-disciplinary theoretical approach of CAS, given that the latter is recognized across a number of allied disciplines. In short, we will outline the advantages that this framework might have as we begin the joint task of developing a research model and methodology for use in HCL.

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2. Three stages of analogical intersections

In order to better address the theoretical aspects of our research framework, one of the first questions that we need to formulate concerns the nature of "language" itself, more specifically, how we conceptualize the object of our research: What is "language"? As Steels (1999: 143) has pointed out: "[For some time now] linguists have been trying to pin down what kind of object […] language is, but this has turned out to be far from obvious." Moreover, we might ask whether that question itself is properly formulated; whether it would not be better to ask "What type of *activity* language is" instead of "What type of *object* language is?" The reformulation of this question will help us to come up with a *systems* approach to its answer.

Before entering into a more detailed discussion of this issue and its relationship to the way we think about language, in this section we will briefly review the impact of evolutionary biological thinking and the analogical transference of some of the concepts from this field to the field of linguistics. Evolutionary biology has inspired the conceptualization of language in three different ways which can be characterized as three basic tropes. They can be expressed as falling into three stages, each of which corresponds to particular developments in the field of biology: 1) language understood as an organism; 2) language viewed as a species and; 3) language considered as a complex adaptive system. Quite obviously this summary requires us to generalize somewhat concerning these modes of thinking about language. If examined with a greater granularity each stage would demonstrate more variation, that is, in terms of the emphasis and focus each conceptualization received from their respective proponents (and critics) (Morpurgo-Davies 1992: 83–97).

2.1. Stage 1: Language as an organism

In the 18th and 19th centuries in biology we find both Lamarckian (Lamarck [1809] 1999) and Social Darwinian models (e. g., Darwin 1871; Spencer [1879] 1978). Both of these models focus on the individual organism and how it relates to other organisms and the environment through competition for resources. The model was constructed through recourse to the dominant "organic" or "organicism" root metaphor of the epoch (Pepper 1942). As a result, focus was on an essentialist, internalized law-governed orthogenesis of the organism. Inspired by these evolutionary ideas, linguists regularly viewed languages as bounded "living beings". The model was one characterized by Linnaean typological and genealogical categorization models with vertical (tree-branching) axis.

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During this period we find the consolidation of the "language-as-organism" trope which was linked to essentialist, typological thinking about the nature of language (Alter 1999; Frank 2008b; Morpurgo-Davies 1992; Richards 2002). We also discover the existence of loose analogical equivalencies between the concepts of "language(s)", "species", "races", and "ethnicities". These resulted in a blend consisting of the equation of "language" to the concepts of "species" and "race", "race" being a concept that was often synonymous with "ethnicity", whereas "species" was viewed in essentialist terms as a type rather than more broadly as a population of individuals. The "species: race" equivalency dates back to the latter half of the 19th century. It was in this period that the earlier 18th and 19th century "language-as-organism" metaphor got caught up in the "species: race" equivalency, fostered by the racial anthropology which was rapidly gaining ascendency alongside its ideological counterpart of Social Darwinism. The conflation of "species" with "race" was facilitated by the fact that the term "race" was often used in biology as an equivalent to "species" (Frank 2008b). Only later did the word "race" acquire its current 20th century meaning in English, i. e., "a local geographic or global human population distinguished as a more or less distinct group by genetically transmitted physical characteristics" (Morris 1969).

Over the course of the 19th century there was a tendency for "language" to be viewed as a "living being" while language "families" were identified with human collectives to such a point that in linguistics terms for languages, races and species became equivalent and were often used interchangeably. But at the same time biology was being inspired by linguistics. During his voyage with the Beagle, Darwin read the linguistic works of von Humboldt, which helped him think about how species interrelate with one another. Tree models, nowadays a common way to depict genealogical and historical relations between species and languages, were first drawn both by Darwin (1859) and Schleicher (1853, 1863). Schleicher argued that languages, like organisms, compete with one another, come into being and die. His linguistic tree models of the Indo-European language family would eventually inspire the taxonomist Haeckel to draw the first non-hypothetical "tree of life", ideas that would again inspire Darwin (Richards 1987: 200–206). In fact, Darwin would take language evolution to be an exemplar for the evolution of species, while linguists such as Schleicher would use the evolution of species to demonstrate that languages are similar to species (Hull 2002).

In this way, genealogical tree models of language relatedness replicated, conceptually speaking, the hierarchy of nature:

phyla → classes → orders → genera → families → species → organisms

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For example, we find Jean Baptise Lamarck (1744–1829) stating: "We give the name genus [genera] to the groups of races, called species, brought together following a consideration of their interconnections […] all the races (what are called the species) which belong to a kingdom of living creatures" (Lamarck [1809] 1999). In short, in the writings of 18th and 19th century biologists race and species were commonly used as synonyms. It would not be until nearly a century later that the English term "race" would acquire its more narrow modern meaning.[1] Even at the time that Charles Darwin (1809–1882) was composing his major opus, the older equivalency was still operating. In contrast, today most readers misconstrue the meaning of the latter half of the full title of his work: *On the Origin of the Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (1859). The second half of the title shows that Darwin was merely talking about "races" of pigeons, among other things. In addition, we may cite Schleicher's equivalencies. Clearly influenced by Linnaeus' taxonomy as well as by Darwin's 1859 work, Schleicher in his *Die Darwinishche Theorie und die Sprachwissenschaft* [Darwinian Theory and the Science of Language] (1863) explicitly equates language families with genera, languages with species, dialects with races, and idiolects with individual organisms (McMahon 1994: 319; Richards 2002).[2]

1 Under "race" *The American Heritage Dictionary of the English Language* lists the following entries, which reflect the semantic shift that has taken place in the term's core meanings since the mid-19th century. At that point in time what are today the fourth, fifth and sixth entries of the following definition would have been among the first to come to mind: "1. A local geographic or global human population distinguished as a more or less distinct group by genetically transmitted physical characteristics; 2. Mankind as a whole; 3. Any group of people united or classified together on the basis of common history, nationality or geographical distribution; 4. A genealogical line, lineage, family; 5. Any group of people more or less distinct from all others, the race of statesmen; 6. Biology a. a plant or animal population that differs from others of the same species in the frequency of hereditary traits, subspecies; b. a breed or strain of domestic animals" (Morris 1969: 1074–1075). An even greater appreciation of the depth of these shifting currents can be gained by consulting the relevant entries in the *Oxford English Dictionary.*

2 A few years later this essay was translated into English and published, in 1869, under the title of *Darwinism Tested by the Science of Language* (1869).

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2.2. Stage 2: Language as species

In the first half of the 20th century we encounter the emergence of the Modern Synthesis and the development of population genetics wherein evolution is mathematically modeled (Mayr 1975). Over time, progress in the field of population genetics would come to influence the field of linguistics and would eventually give rise to the "language-as-species" trope we have today where "species" is understood in its modern, biological sense.[3] Indeed, by 2000, we find this new type of population thinking and concept of "language-as-species" being applied to modeling language, as exemplified by the research on this topic by Croft (2000) and Mufwene (2001). At this point language is defined as "a population of utterances". Hence, we discover a shift in emphasis. In the case of the older "language-as-organism" trope, focus was on *global level* structure and internal agency; language was viewed as a closed, bounded and finely balanced *object*. In contrast, at the end of the 20th century when the "language-as-species" trope comes on the scene, we find increasing emphasis being placed on *local level* structure and external agency: language usage. Moreover, language comes to be viewed more and more as an open, unbounded and constantly changing object. Nonetheless, from this perspective language still is conceptualized primarily as an object, albeit a highly mutable one, rather than as activity.

2.3. Stage 3: Language as a complex adaptive system

Although many instances of system-based thinking can already be found that precede Bertalanffy's (1950) famous article on general systems theory, the latter biologist is mostly regarded as the founder of biological systems theory. Biological systems theory would inspire anthropologists (e. g., Gregory Bateson 1972) as well as sociologists (e. g., Nicholas Luhmann 1984). Typical for systems theory is that it studies biological organisms or cultures as dynamic systems, characterized by the capacity to self-organize and maintain themselves over long periods of time. Nonlinear dynamical systems theory also inspired a new formulation of language: the "language-as-complex-adaptive-system" (CAS) trope. Indeed, the study of complex adaptive systems, a subset

3 As was pointed out in the previous section, the terms "species" and "races" used to be synonymous. Furthermore, especially in Scholastic philosophical discussions of this topic, "species" was a concept used to refer to (essential, bounded) types (Wilkins 2003).

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of nonlinear dynamical systems, has become a major focus of interdisciplinary research in the social and natural sciences and more recently in "evolutionary linguistics" (cf. Lansing 2003; Sole et al. 2005; Steels 2000).

3. An overview of the complex adaptive systems approach and its implementation in linguistics

3.1. General features of a complex adaptive system

Complex adaptive systems are ubiquitous in nature. Typical examples include social insects, the ecosystem, the brain and the cell, the Internet, and also, in general, any human social group-based endeavor that takes place in a socio-cultural system. Broadly defined, a complex adaptive system is one that is self-organizing in which there are multiple interactions between many different components while the components themselves can consist of networks that in turn operate as complex (sub)systems. Since the global and local levels are coupled, this coupling also drives the system to be dynamic at the global level (Hashimoto 1998).

In short, a complex adaptive system is: 1) self-organizing, that is, it is constantly constructed and reconstructed by its users; 2) characterized by distributed control, that is, control is distributed throughout the system. Stated differently, the system has no centralized mechanism of control. CAS thinking is concerned with understanding the global behavior arising from local interactions among a large number of agents. Very often, this global behavior or emergent dynamics is complex; it is neither specified by prior design nor subject to centralized mechanisms of control. And, consequently, it is often difficult or impossible to predict solely from knowledge of the system's constituent parts what the emergent global level properties of the system will be. Complex systems are systems that constantly evolve over time. Thus change is an integral element of their functioning. Complex *adaptive* systems are adaptive in that they have the capacity to evolve in response to a changing environment (also known as adaptability, cf. Conrad 1983). Since complex adaptive systems arise in a wide range of contexts (from the individual cell to the biosphere to culture or the internet), this theoretical framework is rapidly gaining ground in a variety of disciplinary areas.

Of particular note is the close working relationship that already exists between the field of complex adaptive systems thinking and Artificial Life (A-Life), while applications of CAS and related developmental systems approaches to 21st century post-genomic and other types of research problems in the bio-

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logical sciences are becoming increasingly common (Griffiths 2002; Griffiths and Gray 2000; Kay 2000; Lansing 2003; Oyama 2000; Strohman 1997). In all of these areas the principles of emergence and self-organization are fundamental: complex global patterns with new properties can emerge from local interactions. CAS thinking and the related term *complexity science* are used to refer to the loosely organized and highly interdisciplinary academic field that has grown out of the study of such systems, even though the specific theoretical frameworks of the disciplines, fields or subfields in question may differ significantly.

While CAS oriented investigations often tend to be of a highly quantitative nature, as has occurred in the instance of other disciplines, a less quantitatively oriented CAS modeling approach can be adopted for investigating natural language and the formation of metaphors in discourse. In fact, our discussion of the way the analogy of language as "organism" and as "species" developed over time may be viewed as a prototypical example of the workings of a socio-culturally situated multi-agent system, that is, how complex changes in meaning can be viewed as evolving within a complex, socio-culturally entrenched dynamic system. Thus, rather than functioning solely as a tool for understanding the dynamics of artificial factual worlds and computer simulations of language evolution, as has been the case in "evolutionary linguistics" (Steels 2004), the CAS approach can also be appropriated to explore the evolution and socio-cultural entailments found in natural languages (Sharifian forthcoming), as well as to trace the entailments associated with language change itself, most particularly those that leave behind abundant traces in the written record.

3.2. The CAS approach to language

Perhaps one of the most well known initiatives in evolutionary and computational linguistics is that of Luc Steels and his team of researchers working at the Free University of Brussels (Vrije Universiteit Brussel). Steels founded the Artificial Intelligence Laboratory (http://arti.vub.ac.be/) in 1983 where lab-members carry out projects in collaboration with the research units of Sony CSL in Paris. Over the past decade, they have investigated ways in which artificial agents can provide windows on certain aspects of language evolution such as concept and category formation, recursion, compositionality and phonology.

Central to their research projects is the hypothesis that language is a complex adaptive system, one that emerges through adaptive interactions between the artificial agents and one that over time continues to evolve as a self-organizing system, adapting itself to the needs and capabilities of the agents. At the same

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time the system is being structured by the actions of the individual agents. Other related initiatives include the simulation and synthesis of living systems, along with simulations of the co-evolution of language and social structure using various computational frameworks. In some cases the data used in the simulation is itself simulated, while in other cases the data is drawn from natural language(s) and then often modeled or cross-checked using artificial agents (Gong et al. 2004; Hashimoto 1998; Li 1998; Wang, Ke and Minett 2004).[4]

The CAS approach to language states that *global order* derives from *local* interactions. Language agents are carriers of individual linguistic knowledge which becomes overt behavior in local interactions between agents. Through these *local level* (microscopic) interactions agents construct and acquire individual ontologies, lexicons and grammars. When the latter are sufficiently entrenched within the system, they become part of the *global level* (macroscopic) properties of collective ontologies, lexicons and grammars of the speech community. Actually, the process is even non-linear in the sense that individual ontologies, lexicons and grammars continuously contribute to and, in turn, are influenced by the global level. This shift in perspective provides us with a different view of language in which it is understood as a constantly evolving system that defies simplistic taxonomic, essentialist categorization. In short, language is understood as a multi-agent complex adaptive system in which emergent phenomena result from behaviors of embodied, (socio-culturally) situated agents.[5]

As stated, the phenomenon of language is best viewed as a complex adaptive system that is constantly constructed and reconstructed by its users. Therefore, language should be considered an emergent phenomenon, the result of *activity*, the collective, cumulative behavior of language agents over time. These emergent phenomena have a strong causal impact on the behavior and learning of each individual language agent. Hence, there is a type of recursiveness to the

4 We should also mention the research being carried out in computational evolutionary linguistics and simulations of living systems at the Santa Fe Institute; the ongoing investigations taking place at the Language Evolution and Computation Research Unit, located at the University of Edinburgh; the Ikegami Laboratory at the University of Tokyo under the direction of Takashi Ikegami (cf. Ikegami and Zlatev 2007), as well as and the Language Engineering Laboratory, located in the Chinese University of Hong Kong.

5 These dialectics are also pointed out at the psychological level by Herbert Clark (1996: 100–120) when he introduces his famous distinction between personal and communal common ground. And also Tomasello's (2004: 4) characterization of cumulative cultural evolution as a kind of ratchet effect can be interpreted as an attempt to capture these dynamics.

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system in which feedback mechanisms operate as an intrinsic aspect of it. The functioning of these feedback loops is referred to as "circular" or "recursive causality". At the local level the individual language agent's behaviors (utterances) determine language, that is, language understood at the global level. Similarly, at the local level the resulting emergent global level structures of language co-determine the range of behaviors of the agents, that is, the range of possible interactions at the local or microscopic level.

This top-down influence is established in several ways. First, we need to keep in mind that the global level systemic structures of language are already in existence prior to the entrance of the local agents. As such, they act as a strong constraint on the linguistic behavior of individual language agents. While the latter acquire their local level understandings of this already existing system as their idiolect, these are understandings that can be renewed, restructured over and over again in the course of the individual's lifetime. Then we see that the bottom-up influence is established in the following manner. The local level systemic structure of language constantly acts to bring about emergent structure, that is, change, from the bottom-up, so to speak. While the speaker – the individual language agent – has to abide by the structures provided by the system at the risk of not being understood, there is always a degree of flexibility to expand the existing system.[6] Although the structures are to some extent in constant flux, in communicative practice, the speaker is capable of: 1) choosing to draw, consciously or unconsciously, from among them and 2) selecting from amongst those structures that are present in the "feature bank" of her idiolect, her microstructural "knowledge" of the global level macrostructures. From this perspective, in the case of bilingual language agents they can draw on additional microstructural "knowledge" that, in turn, can act to set in motion perturbations in the emergent global level structures.

We must also stress that the above description is somewhat simplified to clarify both the global and local levels. In fact, no linear chain of events can be distinguished. Rather, there is an intrinsic coupling between both levels: both constantly reshape, constrain and influence one another. And also within

6 The close parallels holding between this CAS model and usage-based approaches to language are found in the following discussion of "units of language" where the latter are defined as "not fixed but dynamic, subject to creative extension and reshaping with use. Usage events are crucial to the ongoing structuring and operation of the linguistic system. Language productions are not only products of the speaker's linguistic system, but they also provide input for other speakers' systems (as well as, reflexively, for the speaker's own), not just in initial acquisition but in language use throughout life" (Kemmer and Barlow 2000: ix).

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the local (between language agents) and within the global level (between language communities), interaction is the rule rather than the exception. These interactions again, in a non-linear manner, influence the future of the language system.

3.3. The difference between a CAS and a "species/population" approach to language

At this juncture we might compare the CAS model to Croft's "language-as-species" approach. Rather than employing a single, fused dynamical systems model with input from language agents directly internalized to it, Croft's language-as-species approach operates with two separate conceptual frames. On the one hand, "language" is defined as "a population of utterances" and, on the other, the term "language system" is "used where necessary to distinguish the population definition of language from the view that a language is a system of conventions" (Croft 2000: 239). Croft refers to his model as the Theory of Utterance Selection (TUS) which takes its starting point from neo-Darwinian evolutionary theory. As Croft explains, it was inspired by the Generalized Theory of Selection developed by the philosopher of science, David Hull (1984, 1988). Hull convincingly argues that besides its applications in the study of life, the theory of evolution by means of natural selection can also be implemented in the study of the evolution of culture (e. g., science, language, etc.). He argues that evolution by means of natural selection occurs when replicators (units of selection such as genes or memes) vary due to the differential environmental interactions their carriers undergo (vehicles such as organisms). Such interactions are the stuff selection can work upon and as such they lead to different lineages (populations, demes). By analogy, Croft (2000) argues that language evolution can be characterized by a process whereby *linguemes* (linguistic memes, units of language evolution) vary differentially because of the way the speakers use the linguemes differentially and the way they interact in the linguistic environment. As such, different demes, i. e. populations of utterances, are created and natural selection can work upon them.

Although Croft recognizes the presence of speaker differences and populations of utterances, his early model (2000) does not operate from a CAS perspective and the notion of language as a multi-agent system. Therefore, conceptually his theory does not distinguish the local level from the global level of the same system and/or speak of their inseparability and constant interaction in the way that the CAS model does. For example, TUS tends to refer to the "speaker's knowledge of grammar" on the one hand and on the other

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to the "language system", i. e. an overall system of language conventions. The two concepts are still treated separately, rather than as representing the local and global levels of a single unified dynamic system. Yet there are striking similarities between Croft's language-as-species approach and the perspective afforded by the CAS model. For instance, in 2000, when speaking against the older structuralist (organicist) model of language, Croft stated: "Instead, as implied in this book, the linguistic system is not rigid, homogeneous, self-contained, or 'finely balanced'" (Croft 2000: 231). More recently Croft has described the social cognitive linguistic basis for analyzing language as a complex adaptive system and, in a collaborative effort with the physicist Richard Blythe, he has brought forward a mathematical model of language change that combines the CAS approach with the Utterance Selection Model (Baxter et al. 2006; Blythe and Croft 2008).

In short, a "species" approach to language is entirely compatible with a CAS approach, a topic treated in considerable depth by Steels (1999). Scholars such as Campbell (1960), Cziko (1995), Dawkins (1983), Dennett (1995) and Hull (1988) have demonstrated how a selectionist methodology can be introduced to study not only the evolution of living organisms but also cognition and culture. They convincingly argue that similarly to life, the evolution of culture and cognition also occurs via the selective retention of adaptive variation. Both Croft (2000, 2002) and Mufwene (2001) have incorporated these approaches into their own work. Indeed, Croft (2000, 2002, 2006, 2008) speaks at length of the need to undertake investigations in the area of "evolutionary linguistics" and sets forth an innovative model for doing so. And although Mufwene principally characterizes languages as species, he already toyed with the idea of languages as CAS in his 2001 book. However, Mufwene (2001: 157) exclusively refers to the ecological CAS approach and does not mention the ongoing CAS oriented research in fields such as AI which focus on problems in evolutionary linguistics (Kirby 2009; Steels 1999, 2002).

In sum, given that the two sets of research objectives are quite similar in nature, hopefully researchers will begin to synthesize the two approaches.[7]

7 The search for analogies between selectionist evolution on the one hand and cognitive and cultural evolution on the other is a research avenue that has been undertaken multiple times in the past. This attempt was first systematized in the discipline called "evolutionary epistemology" (Campbell 1960; Gontier 2006b).

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4. The potential of the CAS approach for the study of natural languages

As Briscoe (2002: 1) has observed, "Evolutionary ideas, biological metaphors and analogies have had a rather checkered history within linguistic theory despite their close mutual influence in the nineteenth century". Although a certain amount of linguistic work was influenced by evolutionary and cultural anthropological theory during the fifties and sixties, it is not until the 1980s that we discover the insight that languages *per se* could be studied as complex (culturally) evolving self-organized systems.[8] This position came about in linguistics after the Modern Synthesis in biology and the mathematical and computational work in the field of dynamical systems. Today taking an evolutionary perspective on the origins and development of human language and on linguistic variation and change is becoming more and more widespread. However, for the most part these complex adaptive system initiatives have been restricted to computational and mathematical simulations of language, rather than being integrated theoretically into research on, and concrete descriptions of, natural language systems and, more specifically, diachronic studies of language change.

Scholars working within the field of AI have demonstrated that the selectionist approaches, introduced in the previous section of this study, can be dynamized further when they are integrated into complex adaptive system approaches. In this regard, multi-agent computer simulations of language have also been introduced. Unfortunately, as Briscoe (2002: 3) has observed, the complex dynamical systems approach to language still has not had significant impact in mainstream linguistic theory, perhaps partly because only recently have researchers utilizing this theory started to address questions seen as central to linguistic theory and more specifically to (cognitive) historical linguistics (leaving aside the contributions of Croft and Mufwene discussed previously).

Nonetheless, the shift in viewpoint characterizing many of these ongoing research initiatives in (cognitive) linguistics suggests the following: that in addition to its applications in computer simulations of change (based on multiple

8 The fact that historical linguistics and historical biology can be recognized as two specific areas of a general theory of evolution and viewed through complex systems theory was discussed early on by Stevick (1963: 169), who asserted that "they were particular developments of a general model of persistence with modification of complex systems". In other words, languages and species are both systems which exist and persist through time, while changing as they do (cf. McMahon 1994: 314–340, esp. 335). Furthermore, in the works of Boas (1928) and especially Kroeber (1923), language was already recognized as a self-organizing, "superorganic" structure.

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interactions between artificial agents), a more widespread application of the CAS model to the analysis of *natural* language and concrete long-term language change is not far off. Computer simulations based on the CAS approach provide valuable insights into collective and distributed models of cognition and language evolution, but still researchers are presently unable to build into their computer models the kinds of interactions inherent to the complex sociocultural networks that characterize natural language change over extended periods of time and in real rather than artificial settings (cf. Hurford 2002). Thus, it is conceivable that the results of empirical studies informed by CAS and focused on tracking change over time in real language settings, i.e. longitudinal studies of natural language data, could provide useful new insights into how one might go about improving these computer simulations of language evolution. And, finally, these insights might lead to collaborative studies where the results of investigations on specific changes in a natural language are then modeled, simulated or otherwise cross-checked.[9]

In this way, once we cease viewing language as a closed, bounded "organism" and/or, alternatively, from an exclusively individualistic framework, and begin to contemplate it from a CAS perspective, it would appear that discussions of the mechanisms operating to produce language change(s) could feed into: 1) larger discussions of cognition from a comparative and evolutionary perspective; 2) examinations of the relationship holding between language and culture, where culture, too, is viewed from an evolutionary and cognitive perspective; and finally 3) where the analysis of language change allows insights into the distributed and collective nature of cognition. All of these approaches could be conceptualized from within an integrated or holistic ecological, social, and cultural perspective.

5. Some examples of how one can implement CAS modeling

It is our belief that those working in HCL can profit from becoming more familiar with the work in these allied disciplines of cognitive science which is informed by CAS approaches. More specifically, simulations that integrate CAS modeling and its central notion of self-organization – as it is laid out and discussed by Frank (2008b, 2009) and by evolutionary linguists such as Steels (2004) – are closely aligned with the view of language as "distributed cogni-

9 The article by Li (1998) is particularly exemplary in this respect, for it combines cognitive linguistics methodology and computer simulations in the exploration of a specific instance of language change.

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tion" and with concepts such as "cultural conceptualizations" (Sharifian 2003, 2008, forthcoming), "socio-cultural situatedness" (Frank et al. 2008) and the "extended mind" (Clark 1997; Clark and Chalmers 1998).

The ramifications of CAS approaches to modeling language, namely, approaches that integrate the notion of "distributed cognition" and "socio-cultural situatedness", are further reflected in Croft's discussions about the need to construct "a social cognitive linguistics" (Croft 2008, 2009, forthcoming a). Furthermore, in this respect we would argue that the development of "cognitive sociolinguistics" is an important example of the convergence between the CAS approach and cognitive linguistics (Kristiansen and Dirven 2008). In addition, we would emphasize the fact that cognitive linguistics is witnessing a "social turn" towards variationist studies (Geeraerts 2005). In this sense, it is difficult to imagine language conceptualized as a CAS without taking into account the social structure of language and language communities, i. e. everything that has to do with language variation among social groups. Moreover, with the CAS model these social and variational factors would be viewed as operating dynamically at the global and local levels, as discussed in 3.2.[10]

5.1. Stigmergy: Feedback loops, living systems and language

The kind of feedback loops we have discussed in reference to a CAS modeling of language are not unusual in living systems which are, themselves, self-organizing and complex. In the case of self-organizing systems, feedback loops are sometimes characterized as constituting a form of "circular causality" or they can be viewed as examples of *stigmergy* (Steels 2000; Susi and Ziemke 2001) which is a particular form of distributed cognition. At this point, however, little attention has been paid to the heuristic and inferential potential of stigmergic analogies by those working in cognitive linguistics (Steels 2004). Yet this potential is there since the analogies holding between the concept of stigmergy and language as an "activity" or as "activity-oriented", that is, language understood as a complex adaptive system characterized by self-organization (emergent structure, top-down/bottom-up causality, feedback loops) are quite obvious (Bonabeau 1997; Bonabeau, Dorigo and Theraulaz 1999; Theraulaz and Bonabeau 1999):

10 We would like to express our appreciation to the anonymous reviewer for his/her suggestions concerning the conceptual linkages holding between a CAS approach to language and recent directions in social and variational studies within cognitive linguistics.

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> For example, the path formed by an ant society is an emergent phenomenon of the actions of the individual ants. There is no global coordination nor supervision and the individual ants cannot oversee the total path. Nevertheless the path is more than an epiphenomenon. It plays a causal role in the behavior of the individual ants. The path is formed by pheromones deposited by the ants as they follow the already existing trail. The more ants deposit pheromone the stronger the path becomes and the more the path causally impacts the behavior of the individual ants. Without the path the ants would move in all directions. (Steels 1999: 144)

Stigmergy can be understood as a distributed communication paradigm. When applied to natural language, we might view it as a situation in which natural agents through their individual linguistic choices at the local level interact *indirectly* with each other and where higher frequency patterns of usage are more likely to prevail. Over time the cumulative effect of the (inter-)actions of the members of the speech community serve to transform (or maintain) the shape and/or meaning of a given lexeme or morpho-syntactic feature, that is, by contributing to its (momentary) stability at the global level, again comparable to what Tomasello (2004) describes as the ratchet effect. Thus, there are subtle feedback mechanisms operating over space and time involving socio-culturally situated decision-making processes.

In short, the language system is constantly evolving. The advantage that accrues from studying these stigmergic patterns which are found in natural language is that they are left behind because of the actions of natural human agents. Thus, for us it is not necessarily a matter of studying the way robots and artificial agents should be programmed to make choices and interact with their environments. Rather our attention as cognitive linguists can focus on exploring how to extract these patterns from natural language in meaningful ways, so that the cognitive processes that went into creating them in the past become accessible to us. However, to date, outside of those working in the field of computer simulations of language, i.e., those oriented towards "evolutionary linguistics", few have theorized about natural language processes and change from this perspective, i.e., using analogies to other stigmergic processes found in nature and reflecting on the "activity-oriented" nature of language.

Nevertheless, earlier expressions of stigmergic thinking can be found in Keller (1994) in his discussion of "paths" in relationship to the nature of language change and more recently in Mufwene (2003). Although neither of these authors makes any overt mention of the concept of stigmergy, the language phenomena they are describing as well as the way in which they are attempting to model the linguistic phenomena under discussion could easily be termed stigmergic. Moreover, in the case of the formation and evolution

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of discourse metaphors (Musolff 2008; Zinken, Hellsten and Nerlich 2008), e. g., such as "language as an organism" and/or "language as a species" (Frank 2008b), clearly more than one path is being followed at any one time by the speech community in question and the result is a Borgian-like territory, laced with forking and criss-crossing paths, where some paths gain in salience through repeated use while other tracks fade from view over time through disuse. A similar view could be taken with respect to the formation and evolution of word meaning(s) over time. And, basic to the concept of stigmergy, there is the broader notion of "distributed cognition" and "systems thinking" which has been adapted already by those working in many disciplines within the cognitive sciences.

The possible advantages of adapting the concept of stigmergy and stigmergic thinking and integrating it into the field of cognitive linguistics are readily apparent. With respect to usage-based theories the frequency of use correlates with the notion of "entrenchment" and its effects on different kinds of linguistic units. Indeed, the long term effects of entrenchment on change (and stability) of a given unit have been taken up by a number of researchers. Likewise, the main types of frequency effects cited in CL literature would fit neatly into the usage patterns characterized by stigmergy, i. e., "token frequency" and "type frequency", both of which bring about the entrenchment or stigmergic patterning of different sorts of linguistic units (Croft and Cruse 2004). However, the long term effects of these frequency patterns – the effects of the entrenchment of a given linguistic unit – are not necessarily uniform, as Bybee has demonstrated, all of which suggests that more research needs to be carried on the impact that high frequency (or low frequency) can have on the linguistic unit in question (Bybee 2003, 2006; Bybee and Hopper 2001). These questions in turn require recognition of the distributed two-level nature of the cognitive processes under discussion as well as the way that the forms are transmitted across time and space, from one language agent to another, from one generation of speakers to the next and/or from one speech community to the next, in which there is a constant interaction between the local and global levels of language.

5.2. Language as distributed and situated cognition

The CAS approach to modeling natural language is also closely linked to and aligned with ideas about the embodiment of mind and the environmental situatedness of human cognition, as well as to concepts such as "sociocultural situatedness", "situated cognition", "distributed cognition", "cognitive

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artifacts" and "collective cultural conceptualization". These are notions that are increasingly central to research not only in the areas of AI and A-Life, but also in usage-based investigative approaches encountered in cognitive linguistics. Similarly, there is a greater awareness of the intrinsically diachronic aspect of language as a system and the relative futility of attempts at describing the ontology, lexicon, morphology and syntax of a given language solely from a synchronic perspective, suggesting that, conceptually, the synchronic/diachronic dichotomy is fundamentally flawed when applied to natural languages as systems.

The applicability of complex systems thinking to cognitive processes in general and those found in language is relatively easy to see. More particularly, viewing language as distributed cognition provides a valuable theoretical framework especially when carrying out diachronic analyses of linguistic data. This can be seen in the summary of Waloszek (2003) who lists the characteristics of a systems approach to cognition as follows:

The first principle concerns the boundaries of the unit of analysis for cognition:

- Distributed cognition looks for cognitive processes in the functional relationships between elements that participate together in a process – the traditional cognitive unit of analysis is the individual.

The second principle concerns the range of mechanisms that may be assumed to take part in cognitive processes:

- While traditional views look for cognitive events in the manipulation of symbols inside individual actors, distributed cognition looks for a broader class of cognitive events and does not expect all such events to be encompassed by the skin or skull of an individual.

When one applies these principles to the observation of human activity, various distributions of cognitive processes become apparent. The following three are of particular interest […]:

- Cognitive processes may be distributed across members of a social group.
- Cognitive processes may involve coordination between internal and external (material, environment) structure.
- Cognitive processes may be distributed through time, so that the products of earlier events can transform the nature of later events.

In Table 1 we find various aspects of the traditional view of language contrasted with the systems-oriented approach which integrates the notion of distributed cognition.

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Table 1. *Adapted from Hollan, Hutchins and Kirsh (2000).*

	Traditional View	**Distributed Cognition View**
Unit of Analysis	individual person	all – the system is larger than individuals, all sizes of social-group networks; speech communities
Mechanism	manipulation of symbols and linguistic artifacts by individual actors; synchronic emphasis	functional systems, groups, emphasis on space/time, diachronic dimension
Methodology	controlled experiments, emphasis on cognitive properties of individuals	language viewed as a complex adaptive system, emphasis on cognitive properties of systems, dynamical systems approach, socio-cultural situatedness, ethnography

5.3. Usage-based models

The investigations by Kemmer & Barlow (2000) on usage-based models of language are pertinent, especially the following observations that:

- linguistic structure is intimately tied to language use, i. e., speaking and understanding language; it is not encapsulated in a language-specific module, unaffected by language use after childhood;
- cognitive representations take the form of schemas abstracted over instances of language use, based on entrenched cognitive routines that represent the commonalities found in similar usage events;
- greater frequency of particular types of instances leads to greater cognitive entrenchment, i. e., that frequency of usages in the community shapes the systems speakers learn and use, and in turn usage generates the frequency patterns observed, in a feedback loop;
- usage events play a double role in the system: they both result from and also shape, the linguistic system itself in a kind of feedback loop;
- linguistic entities (categories, structures, etc.) are emergent, and not stored as fixed entities;
- language use and cognition are grounded in the speakers' bodily and socio-cultural experience.

In short, we find their assertion that an analysis of discourse reveals emergent patterns of interaction that align with cultural schemas highly relevant. Moreover, it is clear that linguistic knowledge is an indissociable part of the human cognitive system. In this sense, both linguistic knowledge and its cognitive

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matrix are processing systems, rather than static representational systems or entified superorganic structures, while "language" becomes "activity" (Döring and Nerlich 2005).

5.4. Socio-culturally situated approaches

In addition, although terms such as "language ecology" and "ecolinguistics" are increasingly common in the literature, writers have tended to use "the terms loosely and in a generally ill-defined manner" (Garner 2005: 91), rather than developing a fully socio-culturally situated view of language. Nonetheless, taken together, all of these approaches show the dynamic nature of human cognitive processing and lead us to a more comprehensive picture of the cognitive, embodied, situated, and cultural aspects of human language as well as the importance of the distributed multi-agent aspect of cognition and language.

With respect to efforts to create greater granularity in the definition of concepts such as "language ecology" and "ecolinguistics" we should mention the interdisciplinary nature of the work of cognitive linguists, most particularly that of Sinha (1988, 2004a, 2004b, 2006, 2009), Sinha and Jensen de López (2000) and, for example, Sinha's International Cognitive Linguistics Conference 2007 Plenary Address entitled "Language as biocultural niche and social institution" (published as Sinha 2009). In this paper, Sinha, examines questions such as: how can culture be conceptualized from an evolutionary and ecological point of view, what are the relations between biology and culture, and how do theories of biology and culture bear upon theories of language? Thus, it is now quite clear that cognitive linguists are beginning to appreciate the heuristic value of appropriating biological concepts, such as "emergence" and "biocultural niche", into discussions of language change and language evolution.

In this respect we should mention the early ground-breaking work by Hopper on "emergent grammar" (Hopper 1987) as well as his more recent contributions (Bybee and Hopper 2001; Hopper 2008; Hopper and Traugott 2005; Weber 1997). We should note in particular that Hopper's research deals with "emergence" in relation to historical language change and grammaticalization. Also there are the important research initiatives undertaken by Cowley, co-coordinator of the Distributed Language Group (DLG) (Cowley and Kravchenko 2007; Crowley 2007). DLG is dedicated to exploring applications of the theoretical framework of distributed cognitive systems and the notion of the "extended mind" (Clark 1997; Clark and Chalmers 1998) to language. In a similar vein we should mention that significant work has been carried out by investigators concerned with bringing about closer theoretical ties and thus

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increasing our ability to communicate more effectively across adjacent fields of cognitive science, efforts that in the future could result in far greater interdisciplinary cooperation and synergy (Kramsch 2000; Lantolf 2005; Larsen-Freeman 1997, 2002).

It should be noted, however, that these researchers have been concerned primarily with adopting terminology and concepts drawn from complex systems theory and/or dynamical systems theory and then applying them to specific problems in usage-based linguistics and/or first and second language acquisition and socialization, instead of developing an overall CAS approach and defining the phenomenon of "language" through recourse to it. Therefore, although certainly of significant value, until now, for the most part studies carried out on these topics have not taken up the broader question of how a CAS theoretical model might be applied globally to the concept of "language" itself. However, this situation is about to change. We refer to the fact that a special issue of *Language Learning* dedicated entirely to "Language as a Complex Adaptive System" (LaCAS) is about to appear (Beckner et al. in prep.). The volume will contain papers given at the first conference focusing solely to this topic, held November 7–9, 2008, at the University of Michigan and organized by Nick C. Ellis. The conference proceedings include a contribution by John Holland, one of the pioneers and foremost researchers in the field of CAS and its applications (Holland 1995, 1998, 2005, 2006).[11]

As Ellis observes in his introductory remarks to the conference participants, in the past there has been a disciplinary tendency toward separation and fragmentation of language-related research, increased specialization which has resulted in the investigation of different parts or aspects of language in isolation, even as parsed into separate disciplines. He states that we find "lexis devoid of syntax; we study speech sciences as a separate discipline, psycholinguistics divorced from universal grammar and generative approaches; synchronics from diachronics; we study language structure separate from aspects of social usage or change" (Ellis 2008). By investigating language as a complex adaptive system emphasis is put on the recognition that it is from the interactions among these aspects that patterns of language use arise. Therefore, we believe that "language structure, language acquisition, processing and usage, and language change are not independent from another, but are facets of the same *complex adaptive system*" (Ellis 2008). In short, recent research in the cognitive sciences has demonstrated that patterns of use strongly affect how language is

11 Readers wishing more information on the conference are directed to http://elicorpora.info/LLC and http://www.wiley.com/bw/podcast/lang.asp where the podcast of papers from the conference is available.

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acquired, is used, and changes. These processes are not independent from one another but are aspects of "the same *complex adaptive system* (CAS)" (Beckner et al. in prep). Hence, we allege that the CAS approach reveals commonalities across many areas of language research, including historical linguistics, psycholinguistics, language evolution, first and second language acquisition and computational modeling.

5.5. Genetically-inspired linguistic models

As Beckner et al. (in prep.) point out, the "CAS approach reveals commonalities in many areas of language research, including first and second language acquisition, historical linguistics, psycholinguistics, language evolution and computational modeling". Moreover, another advantage of CAS thinking is that it provides conceptual structure and terminology that is well recognized across the disciplines, while it also avoids some of the pitfalls of more genetically-inspired linguistic models, those that tighten the blend, so to speak, to include, for example, linguistic counterparts of DNA, or even the "genes/memes/lingueme" analogical sequence proposed by Croft (2000). In some instances the heuristic afforded by the biological source can be perceived as exercising excessive control over the conceptual shape of the resulting analogically conceived linguistic target (Ansaldo 2003). Naturally, in the process of developing new conceptual tools for examining language change and exploring the field of evolutionary linguistics, these cross-disciplinary analogies will continue to be developed. At the same time, however, the analogies elicited can give rise to problems concerning their suitability, the one-to-one applicability of the biological source to a particular language phenomenon.

For example, it is difficult to characterize the unit of language evolution. Croft, when introducing the notion of a lingueme, recognizes that "In biological evolution, the gene determines to a great extent the structure of the organism, that is, the organism's phenotype. […] In language use, it seems to be the other way around: the speaker's grammatical knowledge, also called her *grammar*, determines to a great extent the structure of the linguemes" (Croft forthcoming b). Moreover, when speaking of linguistic models that draw heavily on the heuristic provided by biological sources, for those working in cognitive linguistics a certain level of discomfort or even distrust might be elicited by models that have their roots too firmly planted in the Chomskyan modular paradigm, e. g., the genes/memes analogy where language is sometimes viewed as a "meme" or "virus of the mind", or more broadly, where language change is viewed as a process of "exact replication of linguistic information" between individu-

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als and from one generation to the next, another type of epidemiology and a position that dominates in certain sectors of traditional cognitivist thinking (Christiansen 1994: 125–126, in prep.; Deacon 1997: 110–115; Hohenberger 2002: Jenkins 1997, 2000). In contrast we could cite the work of researchers working from within somewhat different frameworks such as Enfield (2003), Gontier (2006a, 2007, 2008) and Sperber (1996, 2000)[12] where the emphasis is on analogies to "horizontal" or epidemiological transfers. A similar perspective is found in recent work on "discourse metaphor" (Chilton 2005; Musolff 2006, 2008; Musolff and Zinken 2009; Zinken, Hellsten and Nerlich 2008).

But the hardest problem we are faced with is the difficulty in locating the site of agency in language. This issue has often been compared to the problem of agency associated with "the theory of the invisible hand", while language itself has been categorized as "a phenomenon of the third kind", based on the fact that it looks like something that was brought about by prior design, but was not (Keller 1994: 61–107). According to Keller, "phenomena of the third kind" can be perceived and described on the micro-level as well as on a macro-level, while he compares language itself to something much more highly complex than a system of footpaths, yet similar in its constitution, an analogy that resonates strongly with complex adaptive systems thinking, the notion of circular causality, as well as that of stigmergy (cf. also Mufwene 2003). Moreover, today many of the systems that Keller listed as belonging to this class of "phenenoma of the third kind" are regularly modeled using a complex adaptive systems framework where agency becomes distributed throughout the system.[13]

6. Concluding thoughts

Over the past two decades developments in the field of cognitive science have brought together pre-existing methodologies and theoretical approaches from a wide variety of disciplines and at the same time promoted cross-disciplinary dialogue relating to the development of new methodologies and theoretical frameworks (cf. Bono 1990, 1993, 1995). As we have noted, this cross-fertilization has been particularly rich in the case of researchers concerned with modeling language in a number of new settings, e. g., those involved in working with artificial distributed agents associated with research projects in AI and

12 Most readers will also be familiar with the seminal work by Sperber and Wilson (2004).

13 For additional discussion of agency in language as well as the difficulties associated with the gene-meme-lingueme equivalencies, cf. Frank (2008b).

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A-Life, as well as in the area of ecolinguistics, biosemiotics and theoretical biology. Whereas a great deal of attention and effort has been placed on developing such models in these subfields of cognitive science, to date less work has been carried out by cognitive linguists. Until now there have been few attempts to develop ways of modeling the entity called "language" through cross-fertilization with frameworks being developed in the hard sciences, specifically, the integration of CAS theory. Nonetheless, in recent years a number of important steps have been taken in this direction, e. g., Croft (2000), Steels (2000), and Bernárdez (2001) and most recently Sharifian (2003, 2008, forthcoming). These initiatives represent a conscious move away from the linear, Cartesian-Newtonian mode of thinking and the linear conceptualization of causality characteristic of earlier models of language and language change and, as such, these steps represent movement toward descriptions of the phenomenon of language more in terms of a self-organizing, dynamic system.

As we have noted, the notion of a self-organizing, dynamic system is central to complex systems theory, also known as dynamical systems theory (Clark 1997). The model now serves as an explanatory device utilized to describe a wide range of natural phenomena and has been adopted also by various disciplines in the human sciences, although not yet by those working in the field of historical cognitive linguistics. Likewise in AI and A-Life it has taken on a central role. Similarly, attempts to model language-like interactions using robotic technology have become commonplace, even the modeling of "artificial societies".[14] Given the possible heuristic advantages that derive from developing a cross-disciplinary vocabulary, a mutually intelligible set of descriptive terms, we believe serious attention needs to be paid to this CAS option as we move forward with the task of elaborating a methodological and theoretical framework for historical cognitive linguistics.

We have explored some of the ways in which CAS thinking might be appropriated to describe the phenomenon of language and language change more effectively. Thus, we have pointed out, albeit quite tentatively, some of the paths that might open up when Croft's "population thinking" approach to describing language is slightly modified in order to bring its conceptual tools more into line, analogically, with the CAS approach. Finally, the linkages holding between the CAS model and current models in cognitive linguistics have been highlighted, e. g., concepts such as "socio-cultural situatedness"

14 Of particular note are the following centers working on "artificial societies": the Santa Fe Institute, the University of Michigan Center for the Study of Complex Systems and the Brookings Institution. Cf. also the *Journal of Artificial Societies and Social Simulation* and Epstein & Axtell (1996).

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(Frank 2008a), "distributed cognition" (Hutchins 1995; Sharifian 2003; Susi and Ziemke 2001) and "usage-based models" (Barlow and Kemmer 2000). In this way, the explanatory power of CAS theory for developing models of natural language has been demonstrated as well as the importance of cross-disciplinary dialogue.

Also, we want to emphasize that our observations concerning the "population thinking" model should not be understood as a rejection of the model as it has been put forward by researchers such as Croft (2000, 2002, 2006) and Mufwene (2001, 2005). Rather we have offered these comments in an attempt to identify ways in which this "population thinking" model could be modified, supplemented and its explanatory power increased by the adoption of the heuristic of CAS thinking: language conceptualized as a complex adaptive system.[15] Indeed, Croft has set forth the groundwork for an "evolutionary model" (Croft 2002, 2006) while his own research already integrates many aspects of the CAS approach to modeling language. And, as we have noted, Mufwene (2001: 157) briefly mentions the CAS approach to language but from a macro-ecological viewpoint. Exactly how this methodological and theoretical revision might be accomplished is far beyond the scope of this short paper although hopefully the topic will be taken up and elaborated upon in more depth in the future.

Given the fact that we are currently engaged in developing innovative methodological approaches and endeavoring to construct theoretical framework(s) appropriate for this new subfield of cognitive linguistics, this juncture presents us with a unique opportunity. It is an opportunity that could allow us to join with the larger community of cognitive scientists who are exploring the role of language in cognition as well as the situated and collectively distributed nature of cognition and language evolution in general, the latter notion being understood as referring both to the origins and evolution of language as well as to the cognitive and cultural processes that give rise to language change.

15 The same would hold for the possibility of enriching approaches put forward by Mufwene (2001) and Keller (1994). In this sense, while Croft appropriates the terminology utilized by Hull, relatively uncritically, Mufwene distances himself somewhat more, drawing on the language-as-species trope, but making it crystal clear in his writings that this metaphorical-analogical appropriation of terms should not be excessively tightened nor understood too literally. In turn, he frequently brings up the many disanalogies that come into play when applying this trope and the heuristic disadvantages of it. In addition, he occasionally brings into play concepts and terminology associated with non-linear systems. At the same time, Croft, too, often expresses his own reservations. Cf. Ansaldo (2003: 123) for further relevant discussion of Croft's model.

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More concretely, while those working in AI and A-Life are attempting to simulate language evolution, inventing multi-agent interactions that give rise to linguistic structure, often in a highly ingenious and noteworthy fashion, those of us investigating diachronic and usage-based questions are surrounded by a vast array of robust data sets that if properly mined would give us insights into natural language events. These evolutionary operations are brought about by concrete populations of flesh and blood speakers whose cognitive acts are imprinted on the data. Hence, the interactions studied are carried out by concrete social collectives over time, rather than being based on simulations using artificial or robotic agents which, admittedly, are run using what are highly complex and sophisticated evolutionary algorithms. In other words, HCL would be modeling the effects of real-world cognition, emergent behaviors and stigmergic effects.

Stated differently, in contrast to the data supplied by studies of "artificial agents" (studies that "feed" on linguistic data) we have access to data sets from natural languages which are the results of interactions of "natural agents". These human agents embody another feature that is of particular importance when reconstructing pathways of change over time: these natural agents are characterized by their socio-cultural embeddedness and their ability to respond to a complex and constantly changing environment. To do this they adapt their linguistic artifacts in ways that seem appropriate to them, that is, by the specific communicative needs of the individual agents within the given setting, at the local level. Hence, it is not merely the interactions between the natural agents that give rise to the reshaping of their linguistic tools, but rather and perhaps more importantly the way that the agents respond, simultaneously, to each other and the shifting demands represented by their socio-cultural situatedness.

Today there is great interest across the disciplines in modeling the evolution of culture, not only the developmental aspects of material artifacts, but also the way cognitive artifacts and material metaphors evolve over time. The following discussion is typical of the manner in which these research questions are currently formulated:

> Culture involves inheritance: a stable transmission of cultural items – such as ideas, skills or artifacts – from individual to individual by social learning. At the same time, culture changes and it often changes in a cumulative and gradual manner. The results of this process include cultural items that are 'adaptive' from the point of view of the culture bearers, apt for the goals the individuals have, who produce and select the cultural items according to their goals. In this sense, cultural change can be seen as analogous to adaptive organic evolution. Cultural change is cultural evolution. (Kronfeldner 2007: 493)

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Little would need to be changed in the above paragraph in order to make it apply to language and language change, other than substituting a word here and there, e. g., "language" for "culture", "linguistic artifacts" for "cultural items", etc.

Thus, there are significant benefits that would accrue by adapting a CAS modeling technique for conceptualizing language, not the least of which would be the fact that by using a framework whose terminology is recognized across the disciplines we would obtain a kind of passport that would allow HCL research to more readily cross these disciplinary boundaries. At the same time the adoption and application of such CAS terminology and associated concepts, e. g., "extended mind", "cultural conceptualizations" and "feedback loops", to linguistic data would allow us to begin communicating in what is already rapidly becoming the *lingua franca* of social and behavioral sciences. In sum, CAS approaches are already part of a cross-disciplinary research framework that is circulating in many subfields within the biological and information sciences. And perhaps more importantly, it is gradually gaining currency in many other related subfields brought together under the umbrella term of cognitive science. In short, since the CAS framework and its related terminology are already widespread in many fields of cognitive science, our adoption of this framework and terminology in HCL would allow for fluid communication across the disciplines and perhaps bring about unexpected synergist results.

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